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History of Scientific Study and Management of the Alaskan Fur Seal, *Callorhinus ursinus*, 1786–1964

Victor B. Scheffer, Clifford H. Fiscus, and
Ethel I. Todd

March 1984

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U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary
National Oceanic and Atmospheric Administration
John V. Byrne, Administrator
National Marine Fisheries Service
William G. Gordon, Assistant Administrator for Fisheries

PREFACE

The "History" by Victor B. Scheffer and Ethel I. Todd was completed in 1967 and 15 mimeographed copies were produced and distributed to the staff of the then Marine Mammal Division, now National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center (NWAFC), National Marine Fisheries Service (NMFS), Seattle, Wash.; the Pribilof Islands Program, NMFS Northwest Region, in Seattle and on St. Paul and St. George Islands; and NMFS Headquarters, Washington, D.C.

The value of the "History" to researchers has long been recognized and to make this information readily available it is being published as written in 1967 with only minor revision of the Literature Cited section to conform to present citation procedures.

Scheffer provided corrections to textual errors and with Clifford H. Fiscus, National Marine Mammal Laboratory, NWAFC, reexamined and selected photographs to accompany the text. Roger E. Pearson, Samuel Waterman, and Rae Mitsuoka, Publication Program, NWAFC, edited the volume rearranging citations to conform to current practice. A Louise Irwin, National Marine Mammal Laboratory, NWAFC, typed the manuscript and with Fiscus verified citations and proofread the manuscript. Leola Hietala, National Marine Mammal Laboratory, NWAFC, typed and assisted in the final production of the manuscript.

Published reports cited in the text are listed in the Literature Cited section. Published reports not cited in the text, but providing additional relevant information, are listed in the References. Unpublished reports and manuscripts are cited as footnotes.

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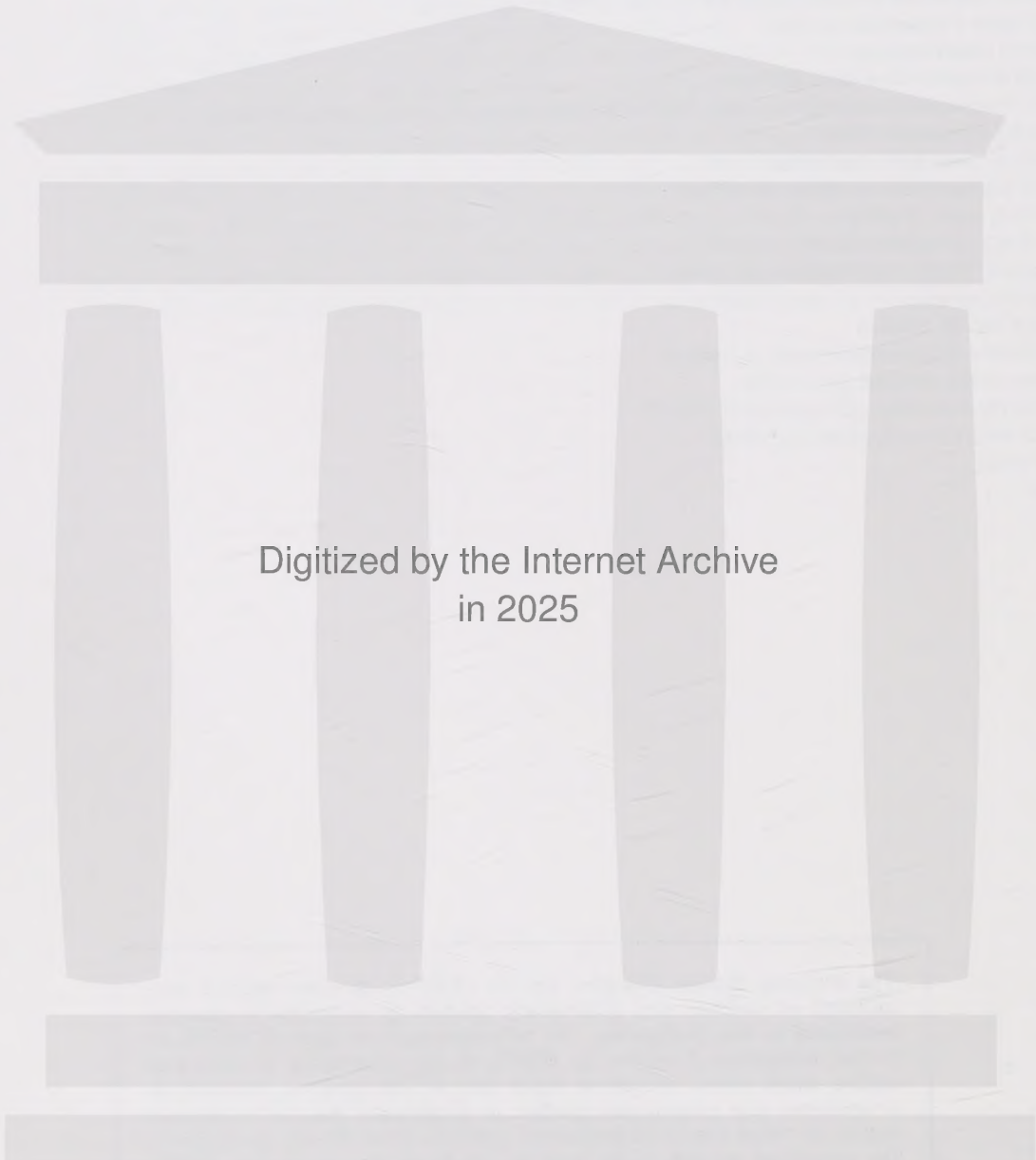

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History of Scientific Study and Management of the Alaskan Fur Seal, *Callorhinus ursinus*, 1786-1964

VICTOR B. SCHEFFER,[1] CLIFFORD H. FISCUS,[2] and ETHEL I. TODD[3]

INTRODUCTION

The breeding grounds of the Alaskan fur seal were discovered in 1786 when the United States was a nation 10 yr old. The seal population has now become a resource of great value and its future seems assured. In the language of wildlife managers, the population has nearly reached the "level of maximum sustainable productivity." There appear to be no biological problems in keeping the population near this level.

Nevertheless, the managing agency—the U.S. Department of the Interior[4]—will continue to be faced with problems of a diplomatic nature rising from the fact that all Alaskan fur seals feed at times in international waters. A few actually land on foreign soil. Research on the Alaskan seal population has been carried out since the early 1890's on efforts to manage it, not only as a national but also as an international resource.

The Department can also expect to face local problems rising from the fact that the welfare of seals and the welfare of people are not always compatible. Certain areas of conflict are illustrated by the following questions: Is predation by seals upon commercial fishes of the eastern North Pacific Ocean and Bering Sea economically important? Should tourism to the seal-breeding grounds be encouraged? How can the future livelihood of the people of the Pribilof Islands be ensured when their population is outgrowing its local base of support (the seal harvest)? What should be the respective roles of the Federal Government and the State of Alaska in conserving the seal herd?

The purpose of the present history is to trace the evolution of zoological research on the fur seals, to discuss the origin and development of research ideas and techniques, and to point out the contributions of research to the present management structure. In discussing past research, we will describe not only scientific studies but also changes in fur seal management and fur seal legislation which have, from time to time, made the studies necessary.

In the fur seal industry during its first century of U.S. ownership, the gap between management and research, or between business (i.e., the narrow view of the fur seal as an item of commerce) and biology, has slowly been closing. It seems clear now that, in order to manage effectively a resource of 1.5 million wild mammals, constant exploratory research must be carried on by zoologists working within the federal management organization itself. Yet, from 1868 to 1939 the seal herd was studied intermittently, and mainly by zoologists borrowed or hired from nongovernmental research institutions. We note that for 45 yr the Pribilof managers had no good way of estimating the age of a seal, yet a simple marking experiment in 1912 finally provided them with a method for so doing. For 80 yr they were saying that the number of births equals the number of adult females, yet a bold experiment in killing and dissecting females ("the sacred cows" of the industry) revealed that the pregnancy rate is not 100% but nearer 60%. These examples indicate the importance of scientific study. The reader will doubtless agree, as he reads the following history, that $1,000 worth of research would, on occasion, have saved $10,000 worth of time on the part of managers, legislators, and diplomats.

THE RUSSIAN PERIOD, 1786-1867

Establishment of the Fur Seal Industry

The first European to see an Alaskan fur seal was Georg Wilhelm Steller, on the voyage of discovery of Alaska. At dusk on 10 August 1741, south of Kodiak Island, he watched a "sea-ape" playing about the ship. He did not then or later recognize it as a seal (Stejneger 1936:278).

In the following summer, while shipwrecked on Bering Island, he saw fur seals returning to land to breed. The species became known to science through the posthumous publication of his "De Bestiis Marinis" (Steller 1751), containing a full description of seals which he saw on Bering Island. The species was given a formal name, *Phoca ursina*, by Linnaeus in 1758. After Steller's 1751 description, little information on *Callorhinus ursinus* was published for a century.

The Pribilof Islands, sole breeding grounds of the Alaskan fur seals, were discovered by the crew of the Russian ship *St. George* under command of Gerasim Gavrilovich Pribilof. The southern island of the group, St. George, was apparently sighted in June 1786. Vague or conflicting accounts of the discovery were given by Sauer (1802), Berkh (1823), Veniaminov (1840), and Tikhmenev (1861-63, part 1, p. 34 in transl.). Sauer's story is perhaps the best. Sauer met "Mr. Pribuloff" at Unalaska in October 1790 (Sauer 1802:210). According to Sauer, Pribilof discovered St. George Island 24 h after he left Unalaska in search of the breeding grounds of the seal. "Observing another island to the north, at the distance of 44 miles, he went thither in a large baidar [skin boat], accompanied by a number of Aleutes. This island is much smaller than that of St. George, and he named it St. Paul's: this, as well as the former,

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[4]At the time this manuscript was written (1967), the U.S. Department of the Interior was the managing agency. However, at publication, the U.S. Department of Commerce is the managing agency.

was the retreat of immense herds of seals. On the island of St. George they passed the winter" (Sauer 1802:211). According to Tikhmenev's account, written 40 yr later than Sauer's, the landing on St. Paul was made during the summer of 1787, after the first wintering.

St. Paul is actually the larger of the two islands. A chart of Sauer's course shows that he passed about 18 mi (30 km) to the westward of St. Paul and could not have seen it distinctly; Northeast Point is shown as a series of dots (Fig. 1). If we assume that St. Paul was discovered on the holy day of St. Peter and St. Paul, then it was discovered on 29 June, old style, or 10 July, new style, 1786 or 1787 (Dall 1870). This would be at the height of the seal breeding season.

The islands were uninhabited by man and were rich in wildlife. During the first year, the hunters took 40,000 fur seal skins, 2,000 sea otter, *Enhydra lutris*, skins, and 14,400 lb (6,500 kg) of walrus, *Odobenus rosmarus*, ivory (Bancroft 1886:191-193).

The Russian period was essentially the period of the Russian-American Company, chartered by Emperor Paul I on 8 July 1799 as a monopoly for trading, hunting, and mining on the northwest coast of America from lat. 55°N northward (U.S. Congress, Senate 1895, part 2, p. 34-70). An imperial ukase to this effect was issued on 27 December 1799 (U.S. Congress, House 1889:xv).

For 1 yr, 1799, the Pribilofs were controlled by the United American Company, a group which was organized in August 1798 and which developed into the Russian-American Company (Baden-Powell and Dawson 1893:197). The charter of the Russian-American Company was renewed in 1822 and again in 1842; it expired on 1 January 1862. The buildings of the Company were transferred to the United States with the sale of Alaska in 1867. "In the first period [1799-1821] of the Company's existence there was peltry but no order. In the second period [1822-40], there was more order but less peltry, and, finally, in the third period [1842-62], there was perfect

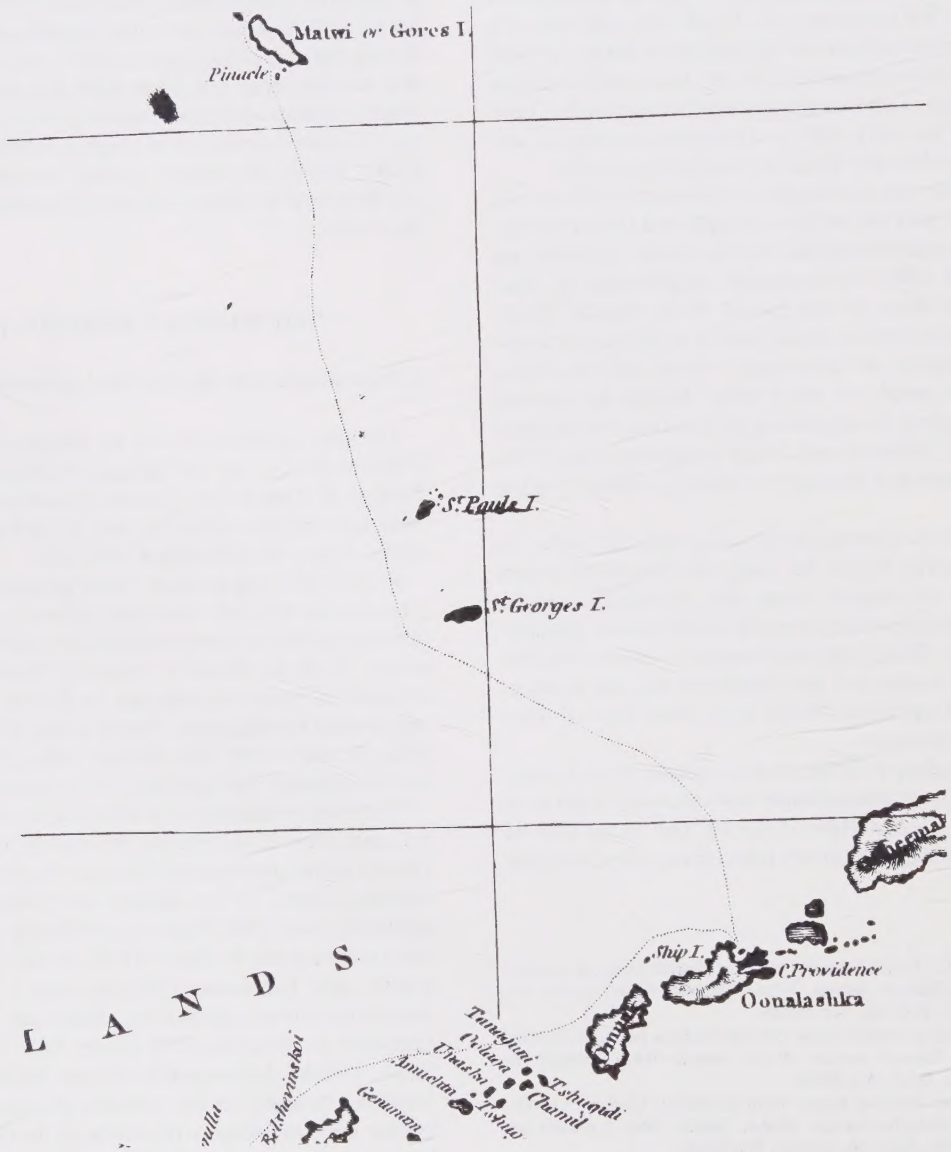

Figure 1.—Earliest known chart of the Pribilof Isalnds. On 12 July 1791 "St. George's Island bore southeast 57°, distant 16 miles; and soon after we saw the island of St. Paul" (Sauer 1802:233) (photo by V. B. Scheffer).

order but the treasury was empty" (Okun 1951:225).

A colorful account of the Pribilof Islands during the Russian regime was written by Fredericka Martin (1946a). She arrived at St. Paul on 25 June 1941 and left during the military evacuation of early summer 1942. She later made an intensive search of early literature on the development of the sealskin industry and the history of the Pribilof "natives."

In 1799, competing traders were sent away from the Pribilofs and the islands passed under the autocratic control of Alexander Baranov. "In 1803, after the slaughter had been conducted for some years without regard to the market, an accumulation of 800,000 skins was found in the storehouses on the islands, 700,000 of which were thrown into the sea as worthless" (McIntyre 1870:16). "In early times" the sealskins were not salted but were cured by air drying, pegged out on the ground or hung on racks near the killing fields (Elliott 1887:369). "The skins were taken from the animals and dried and shipped as goat skins now are. When they arrived in London they had to be softened again. . . . It was not until somewhere in the fifties that the first shipment of salted skins took place, and it was considered a failure in London; but after some further trial, the house of Oppenheim was satisfied that salted shipments made better fur, and they made contract with the Russian Fur Company for fur seal salted, at 14 shillings" [about $2 in 1964], (U.S. Congress, House 1889:78).

Nikolai Rezanov arrived at St. Paul in July 1805 and found evidence of appalling waste in the killing of seals. Noting that "over a million had already been killed [since 1786?]," he ordered all sealing stopped (Bancroft 1886:446). In 1806-07 nearly all the Aleuts were removed to Unalaska. In 1808 seal killing began again, with the help of laborers mainly from Unalaska and adjacent villages. On St. Paul Island the Aleuts were drawn together and huddled into one settlement at Halfway Point (Lembkey 1911d:1038). At the beginning of 1819 the population of the Pribilofs included: 27 Russian men, 379 Aleuts, and no "Creoles" (Tikhmenev 1861-63, part 1, p. 306 of transl.).

From the account of missionary Innokenty Veniaminov (1840) as translated by Elliott (1875:107-116) and Dall (1870:336) the following notes on harvesting of sealskins are taken. From 1786 to 1805, the taking of fur seals was uncontrolled. From 1806 to 1821, slight to no control over killing was imposed from year to year. On 15 March 1821, the Company instructed the fur seal manager, as follows: "We must suppose that a total suspension of killing every fifth year will effectually stop the diminution of the fur-seals, and that it will be safe at the expiration of the close season to resume killing at. . . (fifty thousand annually)" (U.S. Congress, Senate 1895, part 2, p. 44-45).

From 1797 to 1821, the skins of 1,232,374 fur seals were exported from "the colonies" [including Commander and Kurile Islands?] (Tikhmenev 1861-63, part 1, p. 289 transl.).

With the "zapooska" (sparing, letting-go) of bachelors, beginning in 1822, important reforms were introduced. These included a kill quota and provision for a breeding reserve. Bulls were no longer taken and the killing of silver pups[5] was limited to such as were needed for food and oil. All killing was stopped on St. Paul Island in 1822-24 and on St. George Island in 1826-27 (Elliott 1875:107-116; Jordan and Clark 1898a:25).

[5]Silver pup = after the first molt in autumn, the black pelage is replaced by the silver adult type coat (Scheffer 1962:26).

"About 1825, for convenience in handling cargo, the [St. Paul] village was again changed to its present site. On St. George Island several settlements existed originally, but were consolidated at the present site about 1830-1835" (Lembkey 1911d:1038).

"The Russians had a practice of ceasing to take skins when the shedding commenced, and their calendar for this season is our 12th of August" (Elliott 1874, p. [107]).

Killing was again stopped on St. Paul in 1835-37. Veniaminov gave a table predicting the return of seals over the 22-yr period 1835-56. He postulated a five-fold increase in herd size, to be followed after 1856 by a period of stability in which "under the supervision of persons who will see that one-fifth of the [bachelor] seals be steadily spared, 32,000 may be taken every year for a long time" (Elliott 1875:113). From 1835 to 1839 the reported kill was low, $<7{,}000$/yr (Veniaminov [1892]; Riley 1961:9). "It is not clear whether this was due entirely to indiscriminate slaughter or to the combination of this with disaster resulting from the continuance of the ice floes about the islands far into the summer" (Jordan and Clark 1898a:25).

The Company directors wrote on 31 March 1840 to the fur seal manager: "You will bear in mind that we look upon the fur-seal catch as the most important item of our colonial enterprises" (U.S. Congress, Senate 1895, part 2, p. 62).

Elliott (1887:381) believed that 1847 marked the first year "when the females were entirely exempted from slaughter." The St. Paul Island agent wrote in 1847 that skins of 5,607 young males and 1,890 4- and 5-yr males were being shipped. Not again until 1956 were female seals killed deliberately in the Pribilof harvest.

The kill dropped in 1850-52 to $<7{,}000$/yr, for unknown reasons.

"To economize, in 1858 the Company began making seal oil for its ships and machinery. A thousand gallons from the Pribilofs that year saved them five thousand rubles" (Martin 1946a:97).

The Pribilof herd was evidently well conserved in the latter part of the 81-yr Russian regime ending in 1867. In the final decade the mean annual take of sealskins was 30,610 according to Riley (1961:5) and 34,739 according to Sims (1906:34). And in 1864 the chief manager of the Russian-American colonies wrote to the island manager of St. Paul Island "to take hereafter annually about 70,000 fur-seal skins. . . only in case no decrease in the numbers of the animals is observed" (U.S. Congress, Senate 1895, part 2, appendix, p. 89-90). This quota is not far from the mean annual yield of bachelor sealskins, 66,427, during the decade 1941-50 when the Pribilof herd finally reached a population plateau under U.S. management (Riley 1961:7).

In summary the history of sealing in the Russian period is as follows:

1786-1805	Wasteful overkilling; the herd undoubtedly declining.
1806-07	The first closed season.
1808	Killing resumed with slight control.
1822-27	Partial closed season; bulls and pups now spared; introduction of a kill quota and breeding reserve.
1835-39	Period of low annual kills, fewer than 7,000; herd size also probably low.
1847	Females now spared.

1850-52 Period of low annual kills, fewer than 7,000; herd size also probably low.

1856-67 Consistently moderate kills; probably fewer than necessary.

Research During the Russian Period

Little is known of scientific studies on the Pribilofs during the Russian regime. The first published illustration of Pribilof seals was that of Ludovik Choris (1822). He anchored 6 mi (10 km) off St. Paul Island on 3 July 1817 and evidently landed, for his color plate XV is captioned "ours marins [fur seals] dans l'Ile de St. Paul."

The Russian explorer Frédéric Lutké, in the corvette *Le Seniavine*, arrived at St. George Island on 2 September 1826 and lay at anchor for several days (Lutké 1835-36, Tome 1, p. 249-267). Here he met Rezanov, "homme d'un âge avancé" (Lutké 1835-36, Tome 1, p. 250). Rezanov donated three live fur seals to Lutké's scientific collection. The Pribilof population of 225 Aleuts and 17 Russians were then killing up to 3,000-4,000 seals a day on St. Paul and 500-2,000 seals a day on St. George. During the 42-yr period ending in 1828, more than 3 million sealskins had been taken, an average of more than 71,000/yr.

Thirty-six years after the event, Elliott was told by natives that sea ice persisted around the Pribilofs until the middle or end of August 1836. It formed "an icy wall completely around the island [of St. Paul] looming up 20 to 30 feet above the surf . . . . The females were compelled to bring forth their young in the water and at the wet, storm-beaten surf-margins, which caused multitudes of the mothers and all of the young to perish" (Elliott 1887:333). Kirik Artamonov, born on the Pribilofs about 1821, told the same story to members of the Jordan Commission, though the year of the ice was placed at 1834 (U.S. Treasury 1898-99, part 2, p. 466).

According to Hultén (1940), at least seven naturalists visited the Pribilofs between 1805 and 1827 and made plant collections.

Meanwhile, in the United States, the first unhairing and dyeing of fur seal skins was introduced in 1825 by Denison Williams, a cap maker of Albany, N.Y. He may have used Alaskan skins, obtained through London, or he may have used skins from Southern Hemisphere islands. Stevenson (1904:300-301) described the evolution of sealskin processing, and Elliott (in U.S. Congress, Senate 1926:8-9) carried the history to 1922.

In 1836 "an earthquake occurred on the Pribyloff Islands, on the 2d of April. The shock was so severe that people could not stand erect, and was preceded by a loud noise. The rocks were split and broken in many places, and the same phenomena occurred with less violence in August" (Dall 1870:470).

According to Veniaminov in 1840 (Elliott's translation, 1874, p. [148] "sometimes the ice brings bears and red [blue?] foxes. The bears were never allowed to live, since they could not be made useful."

In studying the parasites of Pribilof mammals today it is useful to remember that the islands are not truly isolated but are often in contact with drift ice from continental Alaska, and with the animals transported by ice.

In 1842, a Doctor Warneck ("savant zoologiste de Moscou") collected nine species of birds on St. Paul Island, forming the basis for the earliest account of the Pribilof avifauna (Coinde 1860; Preble and McAtee 1923:122).

The explorer L. A. Zagoskin (1847) anchored off St. Paul Island on 7 June 1842 and visited here several days. "The chief of the village, Shaesnikoff, told us how four days past the ice broke away from the village" (transl., p. 6). A "Behring's Straits Sea-Bear," adult skin and broken skull, was sent to St. Petersburg, to Amsterdam, and to London, where it was catalogued in 1859 in the British Museum as no. 1221a, later no. 1859.1.17.1. Scheffer examined the skull there in 1957; it is certainly a male, estimated age 10 yr. On the basis of the skull, John Edward Gray erected the new genus *Callorhinus* (Gray 1859b:359). Gray had, earlier in the same year (1859a), mentioned the specimen under *Arctocephalus ursinus* (Gray 1859a:103) and had illustrated the skull (plate 68). Allen and Bryant (1870:86) agreed that "the first and only specimen of the *skull* [of an Alaskan fur seal] hitherto figured is that of a male. . . published by Dr. Gray in. . . 1859[a] (Plate LXVIII)."

An early zoological experiment on fur seals was carried out in the 1860's, when the Russian overseer at St. Paul Island "drove up a number of young males from Lukanon, cut off their ears, and turned them out to sea again. The following season, when the droves came in from the 'hauling grounds' to the slaughtering-fields, quite a number of these cropped seals were in the drives" (Elliott 1884:77). Bryant repeated the experiment in 1870.

In 1865 the Russian-American Company tried to improve the curing and processing of Pribilof sealskins. An agent visited London to study the methods of Oppenheim and Company and Lampson and Company. "An attempt was made to entice some expert workmen over from [Lampson] but it did not succeed" (Okun 1951:227).

In 1865, Robert Kennicott (leader), William Henry Dall, and Henry Wood Elliott, naturalists attached to the Western Union Telegraph expedition, visited St. Paul Island. Kennicott died the same year. Dall revisited the islands in 1868, 1874, and 1880. In 1870 he wrote a book, "*Alaska and its resources*," in which he described the fur seals. The book is valuable because it is the first natural history account in English of the Alaskan fur seal. Elliott's many contributions will be discussed later.

In 1868, Charles S. Bulkley, "Engineer-in-chief Russo-American Telegraph," and Charles M. Scammon, "Chief of Marine Western Union Telegraph Expedition, 1865 and 1866," published brief descriptions of the Pribilof Islands under Russian control (U.S. Congress, House 1868b). Although both men visited the islands once or twice, they learned little about the fur seals or the fur seal industry. Bulkley thought that there were at least "100,000 to 200,00 fur-seal" on St. Paul (U.S. Congress, House 1868b:5); Scammon believed that the annual take of sealskins on St. Paul was "usually from 70,000 to 80,000" (U.S. Congress, House 1868b:15).

The father of Priest Innokenty Shayashnikov was a manager of the Pribilof Islands under the Russian regime. "The accidental loss of the elder Shayashnikov's diary destroyed the only written historical record of the Pribilofs for many decades" (Geoghegan 1944:92).

THE INTERREGNUM, 1868-69

Sealing During the Change of Ownership

Alaska was transferred to the United States in 1867 after the Russians had taken the annual seal harvest. The exchange of ratifications took place in Washington on 8 June and formal-

ities were completed at Sitka on 18 October (U.S. Congress, House 1868a:4-5; Dall 1870:359; Bancroft 1886:599; Okun 1951:272). The act (15 Stat. 241 (1868)) appropriating $7,200,000 in payment for Alaska was passed on 27 July 1868 (U.S. Congress, House 1889:ix).

In 1868, at least four private companies set up sealing camps on the Pribilofs and recklessly took several hundred thousand seals. "Original records for the events of 1868 are practically nonexistent and subsequent statements are often exaggerations or apocryphal. Certainly the combinations of San Francisco business men that sent ships to seek out the trading potentialities wanted no publicity. There was no government either on the mainland or the islands" (Taggart 1959:353). The first ship to arrive at St. Paul was the brig *Constantine*. We do not know the date, though it was a few days before 13 April 1868, when the bark *Peru* under Captain Ebenezar Morgan dropped anchor. The *Peru* was owned by Williams, Haven and Company of New London, Conn., and was the first vessel sent from the Atlantic coast to engage in the fur seal business. The first ship to arrive at St. George was the schooner *Caldera* of San Francisco, owned by John Parrott and Company, under Captain R. H. Waterman. She anchored on 24 April 1868 (Alaska Herald 1869:2; Elliott 1886:247; Jordan and Clark 1898a:26).

Thomas F. Morgan, a sealer here in 1868 estimated the Pribilof take at 240,000 (U.S. Congress, Senate 1895, part 3, p. 63); Simms (1906:38) estimated it at 242,000; the Jordan Commission at 300,000 (U.S. Treasury 1898-99, part 1, p. 26). The Jordan Commission assumed that the slaughter of 1868 "did not in any way injure the herd, being confined as heretofore to the killing of bachelors" (U.S. Treasury 1898-99, part 1, p. 28). With modern knowledge of the age and sex composition of the herd, however, we believe that females and yearlings made up half of the kill.

While the slaughter was under way, Congress enacted on 27 July 1868 a stop-gap measure of protection. It forbade the killing of seals within the Territory of Alaska and obligated the Secretary of the Treasury "to prevent the killing of any fur seal...until it shall be otherwise provided by law" (15 Stat. 241 (1868)). By this act, responsibility for conserving the seal herd passed from the Secretary of the Interior to the Secretary of the Treasury (Jeffries 1870:2). The "fur-seal service," as it was usually called, remained in Treasury until 1 July 1903, when it became an independent agency under the Secretary of Commerce and Labor. By joint resolution of 3 March 1869 "the islands of Saint Paul and Saint George [were] declared a special reservation for Government purposes" and it was made unlawful for any person to land on either of them, except by authority of the Secretary of the Treasury (U.S. Congress, House 1889:ix; U.S. Congress, Senate 1895, part 1, p. 38).

The name of Daniel Webster is associated with the early years of U.S. ownership of the seal islands. Born about 1834, he first entered the Bering Sea on a whaler in 1845. From 1868 to 1896 and perhaps longer, he worked as a local sealing foreman on the islands. He was employed by both the Alaska Commercial Company and the North American Commercial Company (U.S. Congress, Senate 1896a, part 1, p. 147). Up to 1878 he lived at Northeast Point, where the remains of "Webster House" can still be seen. In 1870 and 1876 he was absent from the Pribilofs, engaged in sealing on the Robben and Commander Islands, respectively (Thompson 1897:34).

On 7 March 1869, Joseph S. Wilson, inspector of customs for the Treasury Department, arrived on St. Paul island "for the purpose of assisting Inspector La Grange in preventing the landing of persons or merchandise upon any portion of the island..." (U.S. Congress, House, 1898, part 1, p. 9). "After taking possession of the island for the Government" (U.S. Treasury 1898-99, part 1, p. 10), Wilson arranged for military supervision and departed on 27 May. La Grange is not mentioned again; he was presumably the first Government administrator on the Pribilofs.

In 1869, the sealskin harvest was taken by two private firms under Treasury Department regulation. Special agent John T. McLean wrote on 26 October 1869, that "while, from motives of humanity, [the Department] allows the Aleuts to kill the seals for subsistence, the skins of the animals slain are all appropriated by the agents of Messrs. Hutchinson, Kohl & Co., of San Francisco, and Williams, Havens & Co., of New London, no other parties than the agents of these firms being allowed to land on the islands or barter with the natives for the skins" (U.S. Congress, House 1898, part 1, p. 7). During 1870 Hutchinson, Kohl & Company took all skins available until the arrival in late summer of the new monopoly lessee, the Alaska Commercial Company (U.S. Congress, House 1898, part 1, p. 365). In actuality, the Alaska Commercial Company was organized by the members of Hutchinson, Kohl & Company.

Major General George H. Thomas landed at St. George Island on 12 August and at St. Paul Island on 13 August 1869. He found on each island, besides native Aleuts, "a revenue officer, detachment of United States troops, and agents of two [sealing] establishments—these latter...by permission of the Treasury Department.... The revenue officers stated they had restricted the killing of seals to the smallest number necessary for the maintenance of the natives" (Thomas 1870:117). If true, the "natives" must have been very hungry, for the number of skins reported taken was 85,901 (Cobb 1906:32).

On 8 October 1869, Vincent Colyer, Secretary of the Board of Indian Commissioners, landed on St. Paul Island. He found that the Aleuts were killing seals three times a week, taking a total of about 8,000 skins per week (U.S. Congress, House 1870b). He estimated that there were 60,000 skins in the salt houses, and he was told that a steamer had removed a load of skins from Southwest Bay salt house in late summer.

Domestic dogs were prohibited on the Pribilofs in 1869 or 1870. Henriques (1874:15) stated that "during the prohibition of seal killing pending the action of Congress, I was instructed to visit the seal islands...and notify the inhabitants of the prohibition, as well as inform them...that all guns must be given up and all dogs killed." "In September 1870, the Secretary of the Treasury gave written authority to the Company to use fire-arms in protecting the rookeries against marauders.... Between 1871 and 1880 several actual raids were reported, one of the earliest being one by the 'Cygnet'...caught on the 30th August, 1874, shooting seals close to Otter Island, and which raided the rookeries at Zapadnie, St. George Island, on the 1st September, 1874, and again in 1875" (Baden-Powell and Dawson 1893:186). In 1874, Maynard (1898:298) noted that "the use of firearms [for hunting?] is prohibited except in winter."

Information on the first year of controlled sealing, 1869, was summed up in a report dated 9 December 1869 from H. H. McIntyre, "late special agent" of the Treasury Department

(McIntyre 1870). The island was being governed by Lieutenants Barnes and Henderson of the United States Revenue Marine, assisted by soldiers on each island. Two representatives of Hutchinson, Kohl & Company and two representatives of Williams, Havens & Co. were present on St. Paul and a "like number" on St. George. The total Aleut population of the Pribilofs was 371. Congress had enacted a law, approved 27 July 1868, forbidding the killing of seals for commercial use. In February 1869, the Secretary of the Treasury gave permission for "two men selected by each of said firms to remain on each island to care for the property of their principals" (U.S. Congress, House 1870a:13). The Secretary also permitted the Aleuts to "kill such small numbers [of seals] as may be absolutely necessary for their sustenance and clothing" (U.S. Congress, House 1870a:13). McIntyre interpreted this liberally. He instructed Lieutenants Barnes and Henderson to allow the Aleuts to sell skins to the traders, and the total sealskin take for the year 1869 was, as we have stated, 85,901. McIntyre was a business-man's business-man; he became the first superintendent of the Alaska Commercial Company in the following year, 1870.

Research During the Interregnum

In August 1868, Dall revisited the Pribilofs (U.S. Congress, Senate 1895, part 3, p. 22-23). He had landed on St. Paul Island in 1865. When he stopped for 5 d at St. George Island in 1868, he was evidently the first scientist on the Pribilofs after the acquisition by the United States. He took measurements of a freshly killed male and a female seal (Allen and Bryant 1870:78). Under Dall's direction, Henry Wood Elliott later drew the first sketch of Alaskan fur seals since the time of Choris (Dall 1870:489).

Dall subsequently recommended a five-point program for conserving the fur seals. Point 4 specifies that "killing should be restricted to one hundred thousand annually, of which twenty-five thousand should be taken from St. George's, and seventy-five thousand from St. Paul's" (Dall 1870:497). Dall revisited the Pribilofs in 1874 and 1880 but did no research on seals.

Perhaps in company of Wilson, Charles Bryant, first special agent of the Treasury Department, arrived on the Pribilofs "early in March, 1869, but it was not until the spring of 1871 that order was finally brought out of the confusion into which the fisheries had been thrown by the change in ownership" (Bryant 1890:902).

When he arrived on the islands in 1869 "the islands were then in charge of Kazean Shisenekoff, a creole born on the island and educated in the [Russian] school at Sitka.... This Kazean governed the islands twenty-seven years.... He kept a record in manuscript of his observations and left it on the island at his death, but before my arrival there it had been used to paste over the cracks in the ceiling of the hut of one of the natives and so was lost" (Bryant 1880:389).

In 1869, Bryant drew maps—mere sketches—of the islands, and collected the first good series of museum specimens (Allen and Bryant 1870:1, 90, 93). From the six skins and skeletons which he collected, Allen presented a table of measurements and drawings of the skulls and certain other parts (Allen and Bryant 1870:77-82, pls. 2, 3). In 1869 he also made the first "census" of the seal population. On the basis of a total rookery shoreline 18 mi (29 km) long, averaging 15 rods (247.5 ft, 75.4 m) wide, and occupied by 20 breeding adults per square rod (25.3m^2), he figured that there must be 3,133,200 breeding adults and pups (Allen and Bryant 1870:106). This is more than twice the number present today and it was probably an overestimate.

To test the homing ability of seals, Bryant had, in November 1870, 50 young males selected from one rookery, and marked the right ear, and 50 more selected from another rookery, 2 mi (3.2 km) distant from the first, were marked on the left ear. The result was that in 1873, when they were of the proper age to be taken for their skins, four of them were killed on St. Paul's Island, at points more or less distant from the place where they were marked, and two were found on the Island of Saint George (Bryant 1880:401). Still later (1885) George R. Tingle noted one of the bulls that Bryant had clipped 14 yr before in a drive on the reef, indicating a regular return to rookery of birth (U.S. Treasury 1898-99 part 2, p. 280; Jordan and Clark 1898b).

Bryant wrote (1880:390-391) that the Russians killed few seals over 3 yr old because of the labor of handling the skins of older and larger animals. From 1871 to 1873, the Alaska Commercial Company, obliged to pay a fixed tax per skin, raised its sights to larger animals with the thought of making more profit per skin. It found, however, that the skin of a 3-yr-old brought a better price than did skins of larger animals. "From this date [1873] only the three-year-old seals have been taken" (Bryant 1880:391).

Bryant (1880:403) first recorded cryptorchids (males with infantile testes) and hermaphrodites.

"Captain Bryant says that he took, respectively, 18 and 24 seal pups from the stomachs of two killers [killer whales, *Orcinus orca*]" (Lucas 1899d:93). Maynard (1876), a contemporary of Bryant, wrote in 1876 (p. 6) that "a single killer-whale has been found to have fourteen young seals in his stomach when killed." Bryant himself wrote (1880:407) that "in three cases where they [killer whales] have been caught young seals have been found in their stomachs, leaving no doubt of their object in approaching the island." Although we have searched carefully, we have not found Bryant's original account. "On tracing [Bryant's] stories they seem to have no basis in fact so far as the islands are concerned, having apparently been transferred as sailors' yarns from events among the hair seals on the Labrador coast" (Jordan et al. 1898:506). A footnote in a report by Elliott (1876:89) stated that "in the stomach of one of these animals [killer whales] (year before last) *fourteen* small harp-seals were found—Michael Carroll's Report, Canadian Fisheries, 1872."

The following anecdote may represent the only authentic stomach examination of a killer whale on the Pribilofs: "In the year 1868 Mr. E. Norton, while on St. Paul Island, observed a killer chasing seals, swimming with such force that he ran aground and was unable to get off. When the tide went out Mr. Norton cut it open and found three seals in its stomach" (Falconer 1874:59).

Bryant remained on the islands for at least 8 yr, 1869 to 1877 (Bryant 1880:382; Murray 1898b:34). The Jordan Commission listed him (erroneously we believe) as being "responsible for the record in the log of the island of St. Paul" as late as 1893 (U.S. Treasury 1898-99, part 2, p. 256).

As part of his plan to describe the marine mammals of the Northwest coast, Charles M. Scammon took detailed measurements of five female fur seals in an Indian lodge at "Kiddy

Kubbit" (Neah Bay, Wash.) in the spring of 1869 (Scammon 1874:142). He presumed that the seals taken annually here by Indians were of the same stock as those resorting to the Pribilof Islands in summer.

In 1869, Frank N. Wicker, special agent of the Treasury Department, in charge of Alaska, visited the Pribilofs and recommended a management plan for the seals (U.S. Congress, House 1869). It called for an annual kill of 165,000 male seals either under direct Government control or indirect Government control through a lessee. Such a kill would have been about twice the exploitable level.

THE ALASKA COMMERCIAL COMPANY (1870-89) AND THE RISE OF PELAGIC SEALING

Sealing Under a Monopoly Operator

Congress, by Act of 1 July 1870 (16 Stat. 180 (1870)), decided to lease the privilege of sealing on the Pribilof Islands to a monopoly operator. The attorney for the Alaska Commercial Company, in proposing that the privilege be leased to private industry stated: "I do not apprehend that any member of the [House] Committee, or of either House of Congress, is of opinion that the time has arrived for the United States Government to 'go into business,' either as a jobber, manufacturer, or retail dealer" (Jeffries 1870:17). After considering 14 bids, later reduced to 6, the Secretary of the Treasury on 3 August 1870 leased the privilege to the Alaska Commercial Company for the term of 20 yr from the first day of May 1870.

The Alaska Commercial Company was organized in 1868. The original members included Hayward M. Hutchinson, William Kohl, and five others (Johnston 1940). Its ability to manage the fur seal industry was challenged, though unsuccessfully, by other bidders (U.S. Congress, House 1871). For years after the conclusion of the lease, charges of favoritism were leveled at the Government, particularly by the Anti-Monopoly Association of the Pacific Coast (U.S. Congress, Senate 1876).

Along with other provisions of the lease, the Company agreed to kill not more than 75,000 seals annually on St. Paul Island and 25,000 on St. George; to kill only in June, July, September, or October; and to kill only males over 1 yr old. The killing quotas were identical with those proposed by Dall in 1869. The month of August was closed when the skins of young bachelors are in molt. Future changes in the lease were left to the discretion of Congress or the Secretary of the Treasury. On 9 August 1870 the Secretary cut the quota for 1870 to one-half "considering the fact that one-half of the present season for killing fur seals has already expired before the making of a lease" (Johnston 1940:11). The company took in fact only 23,773 skins that year (Sims 1906:38). The lease expired on 31 April 1890, though effectively at the close of the season of 1889 (U.S. Treasury 1898-99, part 1, p. 29). The company was reorganized in 1901 and ceased to exist in 1940 (Johnston 1940:17, 65).

The United States Commission of Fish and Fisheries was established by congressional action in 1871 (Ickes 1943:5). It did not become concerned with the Alaska fur seal industry until 1893.

From June 1870, and during all but 3 yr of its activity in the Pribilofs, H. H. McIntyre was superintendent for the Company (U.S. Congress, House 1889:xxx, 116). He perhaps took the first photograph of Alaskan fur seals. "In June, 1872, I carried a photographer's camera near the Reef rookery. . .and while focusing the instrument, with my head under the black cloth, and the attention of my attendant was diverted, two old bulls made a savage assault on me, which I avoided by dodging and running" (Murray 1898b:85). The results were perhaps the "stereoptican views" which Thomas F. Morgan, of the Company, showed to a Congressional committee in 1889. "They were taken by a gentlemen in 1870, I think" (U.S. Congress, House 1889:60). Morgan himself had been a sealing foreman from 1868 through 1887, except for several years.

From the first full season of operation in 1871, the mean annual kill during the company lease was 93,090 seals, or nearly the allotted quota (U.S. Treasury 1898-99, part 1, p. 208). Food killings by Aleuts accounted for an additional 9,727 seals a year, or a total of 102,819. As late as 1890, 3,000 to 5,000 male pups were being killed annually in late autumn for food (U.S. Congress, Senate 1896a, part 1, p. 146; Bryant, quoted by Jordan and Clark 1898a:82). During the seasons of 1872 to 1874 the Aleut sealing gang took, on the average, about 25 skins/d per workman (Martin 1946a:155). While engaged in skinning, each workman skinned about 15 seals/h (Elliott 1882:74).

"The log of the island shows that in January, 1888, a drive of 500 seals was made from Northeast Point for food. . . . No record is made of any deaths. . .the drive reached the village in good condition in two sections, the time being, respectively, 82 and 100 hours on the road" (U.S. Treasury 1896:38).

The Company regulated the kill in certain years according to the market demand. One of the founders of the Company, C. A. Williams, pointed out that "in one year we took only 75,000, and in another 80,000" seals, though the permitted quota was 100,000 (U.S. Congress, House 1889:101).

Williams also wrote (U.S. Congress, House 1889:110) that, although sealskins were, by long tradition, sent to London for processing, there were two small firms in Albany and Brooklyn, N.Y., "where the skins are as well dressed and dyed as they are in [London]." The U.S. firms in 1889 were not interested in volume business. Not until 1915 did sealskin processing become a full-scale U.S. industry.

In early 1889, when the Company's lease had 1 yr to run, a Congressional committee made a long investigation of affairs on the islands. The committee concluded that the Company was living up to its obligations and that the Government was right in regarding the eastern Bering Sea, as well as the islands, as exclusive property of the United States (U.S. Congress, House 1889:xxxiii).

During the latter years of the lease the Company's quota was obtained with increasing difficulty and a marked decrease in the fur seal herd was apparent. Pelagic sealing was beginning to reduce an already overtaxed breeding stock. (Elliott claimed to have coined the term "pelagic sealing" in 1887 (U.S. Congress, House 1912:67).)

The Rise of Pelagic Sealing

Pelagic sealing was originally carried on by Indians and Aleuts using canoes and spears. Commercial pelagic sealing of Alaskan fur seals may have started on a small scale in 1866, when a Canadian trader, Hugh McKay, carried two or three Indian canoes and their owners on his sloop *Ino* to waters off

Washington and Vancouver Island (Baden-Powell and Dawson 1893:151; Wright 1961:425).

Elliott (1889:141) wrote that gill nets were used in pelagic sealing, though we believe that this use was unimportant. "The pelagic sealer employs three agencies with which to secure his quarry, viz: He sends out Indians with canoes from his vessel, armed with spears; he uses shotguns and buckshot, rifles and balls, and last, but most deadly and destructive of all, he can spread the 'gill-net' in favorable weather."

In the late 1870's, two innovations converted a primitive activity into a business. These were: 1) mother ships, or schooners capable of transporting the canoes and the hunters many miles offshore and into the Bering Sea, and 2) firearms. "The first pelagic sealing in Bering Sea was probably that done in 1880, when nearly 500 seals were taken by Captain Kathgard" (Townsend 1899:224).

The mean annual take first increased and then declined, as follows (Riley 1961:5-6):

1868-1870	5,828
1871-1880	7,193
1881-1890	24,874
1891-1900	42,130
1901-1910	20,986
1911 (last year)	12,671

The maximum pelagic take for a single year was 61,838 seals in 1894. From 1890 to 1911 the pelagic take exceeded, or nearly exceeded, the land take in every year.

The pelagic take at the expense of the Pribilof herd was in fact much higher than indicated by the foregoing figures, which represent seals taken in Alaskan waters only. For example, the data provided by Fraser (1911:32) for the pelagic take from the "British Columbia coast and Bering Sea" show that 346,322 skins were received during the peak years 1893-95, as against 148,941 shown by Riley. The reported data for the last 2 yr of commercial pelagic sealing, 1910 and 1911, are especially low. They are shown by Riley as 795 and 139 seals, respectively. For 1910 and 1911 we have adopted figures provided by J. L. Stoves, of Martin-Rice, Ltd. (in letter of 7 May 1963). In the P. R. Poland Collection, London, Stoves examined the original C. M. Lampson and Company catalogues of public sales. He found:

"Auction 16th December, 1910.
13,584 salted furseal, Alaska.
12,111 salted furseal. N.W. Coast (pelagic)
Auction 15th December 1911.
12,453 salted furseal. Alaska.
12,671 salted furseal. N.W. Coast (pelagic)."

The Poland family has figured conspicuously in the fur seal trade. Ernest and his brother, Henry, were active around the turn of the century (Poland 1892). Rex, son of Ernest, is still writing (Poland 1964). P. R. Poland, son of Rex, is custodian of the P. R. Poland Collection of fur trade records (Ivy M. Sharp, in letter of 1 October 1964).

As early as 1881, the Government declared that the fisheries of the Bering Sea from the Alaskan coast westward to the dateline were exclusively the property of the United States. In 1886, the Government acted upon its theory by seizing three Canadian vessels and one U.S. vessel engaged in pelagic sealing in the Bering Sea (U.S. Congress, House 1889:164, 234; Poland 1892:192; Behring Sea Commission 1893:284; Tomasevich 1943:81). We will discuss later the international uproar which followed.

With the first seizures, and later ones representing at least 12,000 pelagic skins through 1889, it became known to science that the catch in the Bering Sea was two-thirds or three-fourths female, and that females taken as far as 150 mi (250 km) from the Pribilofs were lactating (U.S. Congress, Senate 1895:115).

Research During the First Lease, 1870-89

By 1872 the Government had recognized the need for information on the fur seal herd, particularly for information on its size. Henry Wood Elliott, (Fig. 2) age 25, was therefore sent to the islands. He had been "artist of the Smithsonian Institution and the private secretary of Joseph Henry [first director of the Smithsonian]" (Elliott 1904:9). As a special Treasury agent he arrived on St. Paul Island on 28 April 1872. Throughout a long career, which ended with his death in Seattle on 25 May 1930 at the age of 83, he maintained a burning interest in fur seals. As surveyor, naturalist, author, lecturer, artist, and lobbyist he was the first man to give wide publicity to the habits, environment, and exploitation of the Pribilof seals. His reports were published and republished, especially in Government documents. He last gave testimony on the fur seal herd in 1926, at the age of 80.

On his first assignment he was astonished to find no written record of the location or size of any rookery or an estimate of

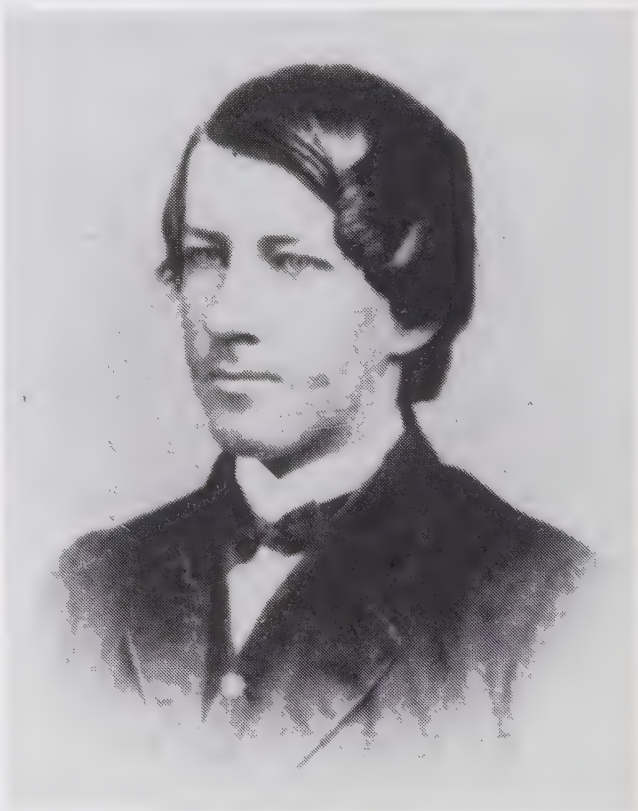

Figure 2.—Henry W. Elliott (1846-1930), first naturalist to study the Alaskan fur seals. He was 25 when he landed on St. Paul Island in the spring of 1872 (photo by V. B. Scheffer).

the number of seals thereupon. "I could at first not believe it; and, for four or five years, I searched carefully among the archives of the old Russian company. . .but was disappointed" (Elliott 1887:332). Was he unaware of Bryant's 1869 census? Elliott mapped the rookeries between 1872 and 1874 (Elliott 1875:76-79). He estimated that on the average, each seal in a harem including breeding adults and pups, occupied "two feet square" (Elliott 1875:77). He meant "two square feet" as indicated by his calculations and by a diagram showing 47 seals crammed into a plot 10 × 10 ft (3 × 3 m) square (Elliott 1898: 335). He calculated that there were 3,193,670 breeding seals and young, and he estimated that there were 1,500,000 nonbreeding seals. "The sum of the seal-life on the Prybilov Islands [is] over *four million seven hundred thousand* (Elliott 1875:79).

Fur seals do not in fact form breeding groups so compact; Elliott's estimate was probably 300% of the actual herd size. His estimate of total rookery area was 6,387,340 ft² (593,403 m²). An estimate made by Kenyon in 1948 on the basis of aerial photographs was 3,566,519 ft² (331,340 m²) (Kenyon et al. 1954:28). Elliott's total area was 1.8 times that of Kenyon's.

Through a compensation of errors, Elliott's figure for total breeding males, breeding females, and young (3,193,670) was almost the same as Bryant's (3,283,200). Bryant had assigned 3.6 times more rookery space to a seal but, conversely, had estimated 3.6 times more total rookery area.

Elliott was present in at least six summers on the Pribilofs, in 1872, 1873, 1874, 1876, 1890, and 1913. Up to 1890 he was widely regarded as an authority on fur seal biology. But, "when, in 1890, Mr. Elliott reached the seal islands after an absence of fourteen years, and found only a scant one fifth of the seals that he saw there in 1876, he impulsively and erroneously concluded that the driving of the young males from the hauling grounds. . .produced impotency and destroyed their usefulness as breeders" (Murray 1898b:55). Elliott's angry report for 1890 was declared by the Secretary of the Treasury to be unfit for publication (U.S. Treasury 1898-99, part 2, p. 302). Elliott was dismissed from Government service on 25 April 1891 (U.S. Congress, House 1911:451). His report was published 8 yr later, though we do not know whether in its original form (Elliott 1898). Jordan and Clark (U.S. Congress, House 1898, vol. 3, p. 714) stated that "it is not for us to say what were the motives which prompted such work. We believe, however, that we are justified in saying that its methods and results can not be too strongly condemned." Elliott recanted, in part, and on 13 April 1892 he stated his new opinion that excessive driving was unimportant as compared with the damage caused by pelagic sealing. He recommended a closed season for a few years on land killing and a permanent prohibition of pelagic sealing (Murray 1898b:127).

An early attempt to salvage fur seal carcasses was made in 1871-72. About 8,000 gal (30,000 l) of seal oil were rendered, but the costs of making it and shipping it to San Francisco were greater than the price it brought (Maynard 1898:297).

In 1874, Lieut. Washburn Maynard, U.S. Navy, was sent to the Pribilofs to inspect the operations of the Alaska Commercial Company and to obtain general information on the fur seal herd (Maynard 1898). He worked with Elliott, though he made an independent report (Maynard 1876, 1898). He observed that the area of a rookery varied as the number of seals, i.e., he recognized the outward expression of the territorial instinct of the fur seal on its breeding grounds. It was more important, he concluded, to measure from time to time the areas occupied by rookery seals than to worry about the actual number of seals. He estimated that the total herd size in 1874 was "not far from 6,000,000" (Maynard 1876:5).

In July, he and Elliott mapped the rookeries and hauling grounds of both islands, using in part the rookery maps made by Elliott in 1872-73. The Maynard-Elliott maps were evidently not reproduced until 1882, in Elliott's monograph of the seal islands. In the preface to this 1882 work are two maps, one of St. Paul Island and one of St. George, with fur seal hauling grounds shown in yellow and fur seal breeding grounds in red.

"The experiment was tried of examining one hundred pups taken at random from the rookeries, and in that number the sexes were about equally divided" (Maynard 1876:4).

We have never understood, for history does not tell, how the managers of the seal herd from 1870 to about 1915 knew that they were killing 2-, 3-, and 4-yr-old bachelors. Elliott (1875:117) wrote of "the annual killing of 100,000 young males over one year and under five." Quite certainly the managers were killing from these age classes, but the question is, how they knew it. We can only conclude that they guessed right. "In assigning the age of three years," wrote Bryant (1880:402), "I have accepted the judgement of the natives, who are familiar with every phase of Seal life, and are governed mainly in their opinion by the appearance of the teeth."

Elliott and agent Samuel Falconer measured and weighed 86 seals of estimated ages 1 to 6 yr on the killing fields of St. George Island in 1873 (Elliott 1875:150). All but about three were males. Their data for size of the yearling male correspond almost exactly to the data given by Scheffer and Wilke (1953) for known-age animals. For older ages, however, the Elliott and Falconer sizes increased much too rapidly. Thus a male of "six years" by their guess measured 72 in (183 cm) and weighed 280 lb (127 kg); by modern standards only 57 in (145 cm) and 134 lb (61 kg).

The first Government chart of the Pribilofs was issued by the "United States Coast Survey" in July 1875 as chart no. 886, scale 1:666,000, with sketches of the islands of St. Paul and St. George at 1:128,300. It was based on surveys by Elliott in 1873-74, on astronomical observations by Dall and party in 1874, and on "surveys of Capt. Archimandritov." Our information comes from this chart and from a later edition, 1890. According to Martin (1946a:138, 143) Ilarion Archimandritov was an Aleut-Russian navigator who had visited the Pribilofs in 1864 as the colonial inspector of the Russian-American Company. He was chief aide to Hutchinson during the first U.S. sealing, 1868.

In 1878, Lucien McShan Turner visited St. Paul Island. He later wrote "*Contributions to the Natural History of Alaska*" (1886) in which he mentioned fur seals briefly, referring his readers to the detailed account of Elliott (1882).

On 20 August 1879, a Dr. White, on St. Paul Island, autopsied a 2-mo-old pup. "Microscopic examination revealed a probable parasite (hookworm?) to the flat parasitic worm (tapeworm?) that infests the intestines of the seal. The long, flat worm is found in the upper part of the bowels. The cylindrical worm (ascarid?), with pointed conical ends, is only in the stomach" (U.S. Treasury 1898-99, part 2, p. 272). Jordan and Clark believed that "these observations seem to have ap-

proached very closely the discovery of the parasite *Uncinaria*" (U.S. Treasury 1898-99, part 2, p. 272, footnote).

One of the first studies of the pelagic life of the fur seal was carried out by James G. Swan, a long-time resident of the Olympic coast of Washington. He arrived at Neah Bay on 27 March 1883 "to study. . .the habits of the fur seals of Cape Flattery, in order to ascertain in what respect, if any, they differ from the fur seals of the Pribiloff Islands" (Swan 1883: 201). From his own observations, and from interviews with Indians and pelagic sealers, he concluded (rightly) that a fur seal pup taken from its mother's body here in June and July can swim actively and may survive in captivity for several weeks. He concluded (wrongly) that the pups may be born on offshore kelp, that the Cape Flattery seals originate somewhere to the southward, and that they differ from the Pribilof stock.

In 1885, Charles Haskins Townsend, resident naturalist of the U.S. Fish Commission steamer *Albatross*, visited St. Paul Island in September and collected 20 fur seals for the Smithsonian Institution. He returned to the Pribilofs eight times, in 1891 to 1896, inclusive, and in 1898 and 1900. He was the first naturalist to examine fur seal stomach contents at sea, when on board the *Corwin* in 1892. He was a member of the advisory board of the Alaska Fisheries Service as late as 1911, at least (Townsend 1887, 1898, 1899, 1905, 1910, 1911; Murray 1898b:19, 51; Osgood et al. 1915:23; Hultén 1940:306). We suppose that he preserved his collections in alcohol, for a St. Paul Islander was "fined for breaking in. . .and drinking alcohol belonging to Charles H. Townsend, naturalist, and becoming stupidly drunk" (Tingle 1898:197).

In 1886, George R. Tingle and L. A. Noyles, Treasury agents, made the fourth "census" of fur seals. It was based on estimates of Pribilof rookery areas occupied by seals, and it yielded an estimate of 4,768,430 for the total population (Tingle 1889:174, 177, 1898:188, 197; Jordan and Clark 1898a:84).

Perhaps the first published photographs of Pribilof scenes appeared in 1889 (U.S. Congress, House 1889). They represent natives and buildings, but not seals.

THE NORTH AMERICAN COMMERCIAL COMPANY (1890-1901) AND THE FIRST INTERNATIONAL TREATY (1891)

On 12 March 1890 the Government re-leased the sealing privilege for 20 yr to another firm, the North American Commercial Company. The Government also reduced the annual quota to 60,000 seals for the first year and reserved the right to fix it annually thereafter (U.S. Congress, House 1898, part 3, p. 452). On 6 June 1890 the Company supervised its first killing and by the end of the year it had taken 20,945 skins (U.S. Congress, House 1898, part 1, p. 241-248). By act of 21 April 1910 the system of leasing was abandoned and the lease of the Company expired on 1 May 1910 (Osgood et al. 1915:24). During the second 20-yr lease, the average annual kill of seals on the Pribilofs was 17,294 (Riley 1961:5-6).

This was barely one-fifth of the take during the previous 20-yr period. What happened to the stock? It is reasonable to assume that the herd was no larger just before the end of the Russian tenure on the Pribilofs than during the 1940's when its growth had stopped and the animals were pressing against the natural population ceiling. With our present knowledge of the breeding potential of the herd, we believe that land killing at the rate of 102,819 seals a year in 1871-89, following the slaughter of the interregnum years, must have included substantial numbers of females and could by itself have been responsible for a steady, though slow, decline in the stock. Pelagic sealing removed mainly females and was the straw that broke the camel's back. According to the records, it drained an average of 14,409 seals a year in the period 1870 to 1889 from waters off North America. The combination of land and pelagic sealing, plus unknown losses at sea incidental to pelagic sealing, may have averaged 120,000 to 125,000 a year.

Was the Company illegally taking females from 1870 to 1889? It can be argued that they were killing no more than a few hundred a year, and these by accident. In the first place, the native sealers were bound by a long tradition of sparing females in the drives. In the second place, Government agents were always present and would have reported any violations of the terms of the lease.

Charles J. Goff, as Treasury agent in charge of the seal fisheries, went to the Pribilofs in early 1890 to assist in the changeover from the Alaska Commercial Company to the North American Commercial Company management (Goff 1891). He and Elliott visited Otter Island on 31 July 1890 and found "that there were no seals hauled out, as was usual in the past" (Goff 1891:3). Had pelagic sealing brought an end to the Otter Island hauling ground in 1889?

Goff was alarmed at the lack of seals on the Pribilofs. "It is evident," he wrote, that pelagic sealing "and the indiscriminate slaughter upon the islands, regardless of the future life of the breeding rookeries, have at last with their combined destructive power reduced these rookeries to their present impoverished condition" (Goff 1891:5). Over the bitter protest of the agent of the new company, he ordered sealing stopped on 20 July. During 1890, only 28,859 seals of the allowable quota of 60,000 were killed. "Notwithstanding the fact that the seals were looked upon as inexhaustible, and were officially reported to be increasing as late as 1888, the time has suddenly come when experiment and imagination must cease and the truth be told" (Goff 1891:5). Thus, Goff, with Elliott's blessing, pioneered in 1890 the practice of closing the sealing season when field conditions warrant it, in advance of a prescribed date.

The Modus Vivendi of 1891-93

By 1891 "the disastrous results of pelagic sealing had become so evident that the governments of the United States and Great Britain agreed upon a modus vivendi [temporary arrangement] of June 15, 1981. . . . It closed the eastern part of Bering Sea to pelagic sealing. . .and limited the killings on our islands to 7,500 annually—the number required by the natives for food. The agreement was put into effect too late to do any good in 1891" (Evermann 1919: 268). The modus vivendi was extended to cover the seasons of 1892 and 1893. The annual kill on land during the 3 yr it was in effect was 14,406, 7,509, and 7,390 (Cobb 1906:32). The pelagic kill was 59,568, 46,642, and 30,812 (Riley 1961:5); closure of the Bering Sea to pelagic sealing in the last 2 yr brought a reduction in take.

As contemplated by the modus vivendi, a treaty was entered into by the United States and Great Britain, signed on 29 February 1892 and ratified on 7 May 1892. Its essential provisions were: "1) The appointment of a commission to make investigations concerning the habits of the fur seal, pelagic sealing,

and the management of the herd on the islands, and 2) the reference of all matters in dispute to a tribunal of arbitration" (Evermann 1919:269).

The Paris Tribunal and Regulations of 1893

The tribunal met in Paris on 23 February 1893 and reached a decision on 15 August 1893. It had been asked, essentially, to judge whether pelagic sealing or land sealing was the cause of the decline of the herd. In a conservative Old World milieu, it decided against most of the claims of the United States and it established certain regulations which would allow pelagic sealing to continue. The regulations were applicable only to citizens of the United States and Great Britain. They provided for: 1) A sanctuary within a zone of 60 mi (97 km) around the Pribilofs, 2) a closed time of 2 mo (May and June) injected in the middle of the season and thus breaking it up, and 3) a ban on firearms in the Bering Sea, but not in the North Pacific. The texts of the decision and the regulations were published (U.S. Congress, House, 1898, part 2). The regulations went into effect in the summer of 1894 and continued in effect until the treaty of 1911. Interesting "reminiscenses of the Bering Sea arbitration" were written by William Williams (1943), last surviving member of the American delegation.

One certain, though perhaps minor, cause of the defeat of the United States before the Paris tribunal was the free-lance diplomacy of Elliott. "His persistent urging of a modus vivendi with Great Britain, the object of which was to stop killing on the islands, while publicly held by him to be a measure necessary for the preservation of seal life, was actually suggested by his secret connection with the Alaska Commercial Company (the recently ousted lessee)" (Lembkey 1911a:453). As a matter of fact, Elliott had admitted before a Congressional committee in 1884 that he was an "expert. . .counsel and adviser in the work on the islands" under salary of the Company (U.S. Congress, House 1884:36). We have seen no evidence that he continued to receive a salary from the Company after it lost the lease in 1889.

Another cause for the defeat of the United States was the Government's embarrassed disclosure that it had not realized until 1890, that the seal herd was declining. The routine reports of the island agents, in the absence of scientific observations, had instilled in the Government during the 1880's a false sense of well-being (Goff 1891; Elliott 1898).

Meanwhile, Japanese nationals, not being bound by the Paris regulations, began to hunt seals more intensively, even within 3 mi (5 km) of the islands. In 1906, 5 Japanese poachers were killed and 12 were wounded on St. Paul Island itself (Cobb and Kutchin 1907:58).

When, in 1894, the Paris regulations went into effect and supplanted the terms of the modus vivendi, the newer ones were seen to be useless. The pelagic take in Alaskan waters doubled in 1894 over that of the previous year. American feeling against pelagic sealing ran high. On 25 February 1896, the House passed a bill (H.R. 3206) which provided that, if Great Britain should fail to cooperate in measures to conserve the seals, "then considerations of mercy as well as of economy and justice demand that we should stop the further cruel starvation of thousands of seal pups by taking what seals are left and disposing of their skins and covering into the Treasury the proceeds, which would probably reach $5,000,000" (U.S. Congress, Senate 1896b:2). The Senate Committee on Foreign Relations agreed but, fortunately for the species, the Senate voted down this spiteful proposal for a final settlement of the fur seal problem.

The United States and Great Britain did agree in mid-1896 to study independently the fur seal problem and to plan for a new look at the treaty in 1898. The study groups of the two nations will be discussed later.

Research During the Second Lease, 1890-1909

In 1890, William Palmer, of the U.S. National Museum, collected plants and animals on the Pribilofs. Among his publications are a detailed account of the Pribilof avifauna (1899) and an appeal for the preservation of the seal herd (1891). He was perhaps the first to present a "screen tour" of the Pribilofs, when he showed lantern slides to the Biological Society of Washington on 17 October 1891.

Edition 2, slightly changed from the original Pribilof Islands chart No. 886, was issued by the U.S. Coast and Geodetic Survey in November 1890.

Elliott took the fifth "census" of the herd in July 1890. Upon his original rookery maps he outlined the areas occupied by seals in 1872-74 as compared with those occupied in 1890 (Elliott 1898:326-382). Again using 2 ft^2 of rookery space per animal, he estimated that in 1890 there were only 959,393 breeding seals and pups, representing 31% of those which had been present in 1872-74 (Elliott 1898:367). We do not find an estimate by Elliott of total nonbreeding seals in 1890. Jordan and Clark (1898a:84) concluded that Elliott's new estimate was "as bad, if not worse," than his older one.

The Aleuts on the Pribilofs did not kill silver pups for food after 1890. Wrote Kirik Artamonov, "The pup seals are our chicken meat, and we used to be allowed to kill 3,000 or 4,000 male pups every year in November; but the Government agent forbade us to kill. . .any more" (U.S. Congress, Senate 1896a, part 1, p. 146).

In 1891, 2 wk after the signing of the first international treaty for protection of fur seals (the modus vivendi treaty of 15 July), the first joint commission representing Great Britain and the United States visited the Pribilofs. The members for the United States were Clinton Hart Merriam (U.S. Bureau of Animal Industry and, later, first chief of the U.S. Biological Survey) and Thomas C. Mendenhall. The members for Great Britain were Sir George Smyth Baden-Powell (brother of the founder of the Boy Scouts) and George M. Dawson (Canadian Geological Survey). Also present, though not as members of the commission, were James Melville Macoun (Canadian Geological Survey), Joseph Stanley-Brown (Treasury agent and son-in-law of President Garfield), and Joseph Murray (Treasury agent) (Murray 1896:58, 1898b:20, 25, 39; Macoun 1899:559; Hultén 1940:307-308). Macoun returned in 1892, 1896, 1897, and 1914 to botanize. We will discuss later the results of the Bering Sea commission.

Stanley-Brown's independent assignment during the summer of 1891 was to obtain evidence that pelagic sealing, rather than overkilling, overdriving, and disturbing seals on land, was responsible for the visible decline of the herd. He later (Stanley-Brown 1894) published an article on the "*Past and future of the fur seal*," a perceptive analysis of the Paris regulations and their predicted effect on the herd.

He was engaged in 1891 and also in 1892 in "continuous general examination of all the rookeries and the plottings of

the breeding-ground areas upon charts" (Stanley-Brown 1896: 157). In his report for 1892 he wrote that "upon charts of a scale of 264 feet to the inch [1 to 3,168] have been placed my observations as to the areas occupied by the seals during the past two seasons. These maps have been lithographed, and upon them as a base has also been placed all information obtainable from other sources concerning the oscillation of the rookeries" (Stanley-Brown 1898:316). He stated that 11 "seal rookery charts" (A-K) were filed in Washington in 1891. He photographed the rookeries from "fixed stations indicated on the charts."

The Marine Mammal Biological Laboratory[6] recently obtained a set of the charts "surveyed by Joseph Stanley-Brown, 1891." They show land contours; the sea is printed in light green; symbols indicate the approximate rookery areas. The charts show (with original spelling): Reef and Garbotch, Northeast Point, Polavina, Tolstoi, Lagoon, L(illegible) Zapadnie, (illegible) Zapadnie, Ketavie, Lukannon, Zapadnie (St. George), Starry Arteel, North, East, and Little East. Hand work was added to the printed charts by Stanley-Brown, C. H. Townsend, and perhaps others. In black and red ink there were indicated:

1. Breeding grounds in 1892.
2. Breeding grounds in 1896.
3. Hauling grounds in 1896.
4. Camera stations by number. The numbers were painted on rocks the following year (1897) and have been renewed at intervals down to the present. The camera stations of the 1890's were not, however, exactly those in use today. Thus "Photo. Stat. 14" of the "Ketavie" chart is now simply a number-painted rock southwest of Kitovi Amphitheater.
5. Camera stations by letter. These evidently do not correspond to the modern stations. Thus "Photo. Stat. G" of the "Polavina" chart is no longer in use; the only stations on Polavina are B, B_1, and B_2.

The Marine Mammal Biological Laboratory charts are in seven pieces; we are unable to reconstruct the original format.

Stanley-Brown had permission to kill fur seals for research purposes, for he shot "with a noiseless rifle" and later dissected three female seals at Northeast Point. (Later, under terms of the treaty of 1911, biologists on the Pribilofs were not allowed to kill seals for other than commercial use.) He threw eggshells filled with blue paint at females for the purpose of marking them.

Evidently believing that the Treasury Department should not be burdened with biological matters, Stanley-Brown recommended in 1892 "that Congress be urged to require from the Fish Commission an annual report of the condition of the rookeries" (Stanley-Brown 1898:339).

"Two 2-year-old fur seals were taken down to San Francisco in 1891 to the Woodward Gardens. They refused to eat anything, and escaped once by climbing a wire fence. They were retaken, but died in about six months. They must, of course, have eaten something to have lived so long" (Jordan et al. 1898:381).

[6]Marine Mammal Biological Laboratory is presently National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Murray was beginning to develop in 1891 a method, based on the size of the average harem, of estimating the number of rookery seals. He walked twice in July along all of the rookeries of St. Paul Island and concluded that there were 481,350 breeding females (Murray 1896:59).

The joint report of the Bering Sea Commissioners was signed 4 March 1892 (Behring Sea Commission 1893:11). It was essentially an agreement to disagree. It was followed soon by a report of the U.S. members, signed on 30 June 1892 (Mendenhall and Merriam 1895), and by a report of the British members, signed on 13 August 1892 (Baden-Powell and Dawson 1893:13).

Here was presented the first statement by naturalists that "the fur-seals of the Pribilof Islands do not mix with those of the Commander and Kurile Islands at any time of the year. . . . The pelage of the Pribilof fur-seals differs so markedly from that of the Commander Islands fur-seals that the two are readily distinguished by experts" (Mendenhall and Merriam 1895:323-324). Now we know that the seals intermingle, and we believe that eastern and western stocks are anatomically indistinguishable.

Here, also were presented (Mendenhall and Merriam 1895, opp. p. 352 and 354) the first life tables for male and female fur seals. For each sex, a mortality of 50% during the first year, and a maximum life span of 20 yr, were postulated. These estimates are reasonably valid.

The commissioners examined the stomachs of 118 seals killed on the islands on 1 and 3 August 1891 and found them nearly empty (Mendenhall and Merriam 1895:393). They reported Townsend's analysis of stomachs of 104 seals killed off southeastern Alaska, 22 April to 1 May 1892. The stomachs contained squid; rockfish; walleye pollock, *Theragra chalcogramma*; lingcod; salmon; and stickleback (*Gasterosteus* sp.) (Mendenhall and Merriam 1895:394).

Merriam (1896) independently sent a circular letter on 2 April 1892 to 12 leading zoologists of the world. It outlined the biology of the fur seal, described the history of the fur seal industry, and called for an end to pelagic sealing. The replies were overwhelmingly in favor of his stand.

The report of the "British Behring Sea Commissioners" was finished on 13 August 1892 (Baden-Powell and Dawson 1893). They showed a "track chart of routes followed" from 15 July to 8 October 1891 (map no. 1 facing p. 150). They touched at the Pribilof Islands three times, at the Commander Islands, and at other points on the North American and Siberian coasts. The report did not give important findings on land, for the two men were on the Pribilofs for only 2 wk in August and September. The report is, however, important in giving a thorough historical summary of the "former, present, and prospective condition of the fur-seal fishery in the North Pacific Ocean" (Baden-Powell and Dawson 1893:3).

They stated (Baden-Powell and Dawson 1893:19-22, 194, diagram no. 5 facing p. 150) that the Pribilof kill for 81 yr under Russian control, 1797 to 1866, averaged about 34,000/yr. From 1867 to 1869 it averaged over 130,000, and during the first lease, from 1870 to 1889, it averaged 94,739, not counting about 4,600 pups/yr. They pointed to statements of the Alaska Commercial Company superintendent, H. H. McIntyre, who began to notice a decrease in average size of seals in the drives as early as 1883 (Baden-Powell and Dawson 1893:27, 177). They pointed to a gradual and deliberate lowering of the standard weight of skins (1893:178). They pointed out (1893:177)

that the official reports of Goff and Elliott in 1890, describing an alarming decline in the herd, were still unpublished in midsummer 1892. They concluded: "A critical investigation of the published matter, together with the evidence personally obtained from many sources and an examination of the local details of the rookeries and hauling grounds on the Pribyloff Islands, leads us to believe that there has been a nearly continuous deterioration in the condition of the rookeries and decrease in the number of seals frequenting the islands from the time at which these passed under the control of the United States" (Baden-Powell and Dawson 1893:23).

Baden-Powell and Dawson (1893:46-50) recommended a general tightening up of methods of killing seals on land and sea, reduction in the total killed, and concurrent action by the four nations of the North Pacific.

In 1892, Barton Warren Evermann "as a special commissioner under the State Department, made extensive studies regarding pelagic sealing in the North Pacific. In the course of his investigations he visited the Pribilof Islands" (Osgood et al. 1915:23). From 1903 to 1910 he was in charge of the Division of Scientific Inquiry of the Bureau of Fisheries, and when the Alaska Fisheries Service was created on 4 March 1911 he became its first chief. He became director of the California Academy of Sciences in 1914 (Evermann 1912:5; Hanna 1932a:317, 1932b:162). Evermann (1919, 1922) maintained for many years an interest in fur seal conservation.

A completely new chart no. 8990 of the Pribilofs was issued in April 1892.

In 1893 the Commissioner of Fisheries was "authorized and required to investigate. . .and when so directed to report annually. . .the condition of seal life upon the rookeries of the Pribilof Islands" (U.S. Congress, Senate 1896a, part 2, p. 3). Though the Treasury Department continued to manage the fur seal industry, the Fish Commission now became responsible for research. C. H. Townsend directed the research from 1893 to 1895. He had been on the islands in 1885, 1891, and 1892 as naturalist of the *Albatross*.

In 1893 he marked with white paint certain camera stations on both islands. According to Jordan (U.S. Treasury 1896:21) he painted "a white cross on a rock at the head of each of the large masses of breeding seals as located at the height of the season [mid-July]." In 1893 he made "46 photographic views"; in 1894, 38 photographs; and in 1895, 42 photographs (Townsend 1896, part 2, p. 3-5, 10, 27). The photographs taken in 1895 by Townsend and his assistant N. B. Miller were later reproduced (Townsend 1896, part 2-Atlas). They are a valuable record of seal distribution on the breeding grounds at a low point in herd size.

Some of Townsend's investigations were made on the islands and some among the pelagic fleet. He reported the contents of 32 seal stomachs collected at sea in 1894 by A. B. Alexander (Townsend 1896:22). The contents were squid, pollock or cod, and salmon (?). In 1895 he examined 73 stomachs containing food and reported the contents as squid, pollock, cod, salmon, and "very small fishes" (Townsend 1896:42).

In 1894, Joseph Murray, special agent of the Treasury Department, again visited the Pribilofs to compare the numbers of seals killed "with what they were every year since [he] first saw them in 1889" (Murray 1898b:3). He observed large numbers of idle bulls and starving pups, the result of pelagic sealing upon females. He estimated that "no matter how many seals were there in 1891, not to exceed one-half of the number were to be found in 1894" (Murray 1896:59). He returned to the islands in 1895.

In 1895, females were first dissected for study of reproductive condition as evidenced by appearance of the mammary gland, uterus, and ovaries (Townsend 1896:41). Townsend examined 106 females and concluded that "female fur seals are first impregnated at the age of 2 years, and bear their first young at the age of 3. It is also apparent that nursing females are already pregnant when they begin feeding at sea" (Townsend 1896:42). (We now know that the female is first impregnated at age 3 yr or older.) Townsend's tally of 78 nursing females in 80 females "3 years of age or older," taken between 11 and 21 August, suggests a high pregnancy rate, about what one would expect to find in waters near the islands in midsummer (Townsend 1896:45).

In 1895 Townsend plotted in color, by months, the location of pelagic catches in the North Pacific and Bering Sea (Townsend 1896, opp. p. 96). He prepared a similar, though more elaborate, chart covering the catches from 1883 to 1897 which was published at the conclusion of the Jordan investigations (Townsend 1899, opp. p. 234).

In 1895 Townsend cooperated with F. W. True, "curator of mammals, United States National Museum," who spent July and August on the islands (True 1896; Osgood et al. 1915:23). True evidently planned to give a full report of the natural history of the fur seal but did not do so. He collected 15 seal specimens for the Museum. He later (True 1899) published a general account of the mammals of the Pribilofs excluding the fur seal.

In 1895, four independent "censuses" of fur seals were made. The methods and results were analyzed by Jordan and Clark (1898a:85-88) and Clark (1912:895). The number of breeding females in the Pribilof herd was estimated by Townsend (1896:34) at 65,239, by True (1896:107) at 70,423, by Murray (1896:373) at 200,000, and by Crowley (1896:35) at 99,936. Murray introduced the important technique of counting harem bulls (5,000) and multiplying them by the average harem (40 breeding females). His method was the best that had been developed. Osgood et al. (1915:34) wrote that the method of the average harem was used "during pelagic sealing or in all years previous to 1912" to estimate the number of pups born. Murray wrote in 1894 that "I have for six years paid particular attention to the formation of the harems or families, and I find that from July 10 to 20 the rookeries are fullest and at their best" (Murray 1896:49). The practice of beginning the annual bull count on 15 July, a practice which became routine in 1904, may have originated in the observations of Murray.

The Paris regulations of 1893 were ineffective. The reported pelagic kill for 1894 reached an all-time high of 61,838 seals while the kill on land was only 15,033. "The United States, therefore, requested Great Britain to consider the revision of the regulations. This request was declined, and in 1896 this country accepted the proposal of Great Britain that the two countries institute independent scientific investigations of the entire matter" (Osgood et al. 1915:22). The second joint commission visited the Pribilofs in the summers of 1896 and 1897. Its members were, for the United States: David Starr Jordan, Jefferson F. Moser, Leonhard Stejneger, Frederic A. Lucas, Charles Haskins Townsend, George Archibald Clark, and Joseph Murray. Those representing Great Britain were D'Arcy W. Thompson, Gerald E. H. Barrett-Hamilton, James M. Macoun, and Andrew Halkett. (Macoun returned in 1914 as an old man, with the Osgood, Preble, and Parker commission)

(Hultén 1940:308; Hanna 1960:14[7]). Stejneger stopped briefly at St. Paul Island in July 1922, en route to the Asiatic fur seal islands (Stejneger 1923:34). Jordan (1922, vol. 1, p. 550) wrote, "A Japanese group had also been appointed, but its members were unable to reach Bering Sea; they did, however, join us at Washington in December" 1897.

On 7 November 1896, Jordan and associates issued a preliminary report which was published the same year (U.S. Treasury 1896). It offered the first map (U.S. Treasury 1896, folding map at end, untitled) purporting to show the migration routes of American and Asian seal populations. It emphasized (U.S. Treasury 1896:36) the "need of scientific supervision of the breeding herds" and called for "improvement and extension of the rookeries" by landscaping tools and machines.

On 1 November 1897, Jordan and associates issued a second preliminary report (U.S. Treasury 1898). It was a forerunner of the four-volume final report of 1898-99, which we will describe later.

In his brief report of studies during the summer of 1896, D'Arcy Thompson concluded that "the alarming statements to which utterance has been given in recent years, the accounts of the herd's immense decrease and the prophecies of its approaching extinction, are overdrawn and untenable" (Thompson 1897:35). He believed, however, that the population was in precarious balance and was definitely not increasing.

Barrett-Hamilton (1897) visited Robben, Bering, Medny, St. Paul, and St. George Islands in one summer; something of a record!

His Canadian colleague, Macoun, blamed U.S. management of the resource for the decline. "Long before pelagic sealing could have had any effect upon the condition of the seal rookeries, a great decrease was noted in the number of seals of both sexes on the islands. This decrease can be attributed to no other cause than the excessive killing of male seals, the annual quota of 100,000 leaving an insufficient number to mature for procreative purposes" (Macoun 1897-98:74).

At the conclusion of the 1896-97 field investigation, representatives of both nations signed, on 16 November 1897, a carefully worded joint statement. They agreed that the annual yield of Pribilof sealskins had fallen to one-third or one-fifth of its former level, that the mortality of pups on land was about 20%, that the pelagic catch contained a high percentage of females, and that "the take of females in recent years has been. . .far in excess of the natural increment" (Jordan and Clark 1898a:243). They concluded that the fur seal as a species was not threatened with extinction, though as a natural resource it was yielding an "inconsiderable" return, both to the lessees of the islands and to the owners of the pelagic fleet. Their estimate of 20% mortality for pups apparently included 9% for pups dying before 10 August of "natural" causes and 11% for those dying later of starvation after the death of their mothers at sea.

In the following month, on 29 December 1897, the United States "passed a law [30 Stat. 226 (1897)] making it unlawful for any of its citizens to engage in pelagic sealing at any time or in any waters, thus putting squarely upon the British and such other nations as might engage in pelagic sealing the entire responsibility for such results as might follow from killing seals on the open sea" (Evermann 1919:269). The text of the act was given by Jordan and Clark (1898a:246).

The scope, the personnel, and the itinerary of the investigation of 1896-97 were summarized by Jordan and Clark (1898a:17-22). Among the results were the following important contributions to fur seal biology.

1) The best "census" of seals up to then was prepared in 1897, and a preliminary census for 1896 was refined. The estimates were based on complete counts of harem bulls and partial counts of harem females and pups. (This technique had been developed by Murray in 1891, 1894, and 1895.) The total estimate of Pribilof seals "present at one time or another, season of 1897" was 402,850 (Jordan and Clark 1898a:100). "The method of enumeration thus established in 1896 has been continued each season since with slight variation" (Clark 1912: 895). Thompson (1897:19) gave useful summary, by rookery and by class of seal, of the five "censuses" of True and Townsend, Murray, Crowley, and Jordan, in 1895 and 1896.

2) A critical review of existing rookery maps was undertaken by Moser (1899:321) during 10 d in July 1896. Maps had been made by Elliott, Townsend, Stanley-Brown, and "Drake" (presumably F. J. Drake, the commander of the *Albatross* in 1895). Moser concluded that "it is impracticable to correct the present rookery maps" (Moser 1899:324). He proposed that a survey party of about seven men be assigned for a full year to make new ones. Numbers were painted "in 1897 on rocks by the surveying party of the United States Coast and Geodetic Survey, to mark the approximate boundaries of the various rookeries on the islands" (Lembkey 1908:32). We believe that these are the numbers now in use. (Townsend had made crosses, not numbers, on rocks in 1893.)

The Coast and Geodetic Survey sent a party under Will Ward Duffield to the islands in 1897. They painted certain rocks along the rookeries and prepared 15 new charts (nos. 3214 to 3228) of the rookeries and the islands, with modern spelling. The charts were published in May to July 1898. The Marine Mammal Biological Laboratory had in 1965 only a partial set of charts, though a complete set of photo negatives of the charts.

3) A detailed record of all seals killed for all purposes, by rookery and by day, from 1870 to 1897, was compiled by Murray (1898a:364-407). The total kill for the 28 yr was 1,977,337; the mean annual kill was 70,619.

4) Anatomical studies of the fur seal were carried out by specialists attached to, or cooperating with, the Jordan Commission: Lucas (1899a:9-11, 2 pls.) on dentition; Snodgrass (1899: 11-21, 2 pls.) on alimentary, circulatory, and genitourinary organs; and Fish (1899:21-41, 3 pls.) on the brain.

5) The studies by Lucas (1899b:43-57, 1 pl.) on breeding behavior and physiology of the seal were especially important. Dissections by Townsend in 1892 aboard pelagic sealing vessels had brought to light information on fundamental female anatomy. Later studies at sea, combined with Lucas' work on land in 1896 and 1897, brought evidence on the estrus, the fact of annual rather than biennial breeding, and the scarcity of barren individuals. The percentage of females in the pelagic kills of 1894 to 1896 was shown to be about 80% (Jordan and Clark 1898a:185). Because marked animals of known age were not available to them, biologists up to 1914 believed that "the female is sexually mature at the age of 2" (Lucas 1899b:48).

[7]Hanna, G. D. 1960. [Transcript of a tape recording, 18 June 1960, on St. Paul Island, entitled "A comparison of conditions on St. Paul Island during 1913-1920 with the present."] 24 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

6) The causes of mortality among seals were described and their effects were evaluated. The hookworm "*Uncinaria* sp." was discovered (Lucas 1899d:75-98; Stiles and Hassall 1899: 99-177). Dead pups were counted on all rookeries for the first time in 1896; mortality before 10 August was estimated to be 9% (Jordan and Clark 1898a:95, 214). The seal louse *Antarctophthirus callorhini* was described by Osborn (1899:553). (See also Ferris 1951:300.) A tick (*Ixodes arcticus*) also described, has never been found since on fur seals; the original specimen was evidently mislabeled. In 1897, "upward of 12,000 carcasses" of worm-infested pups were collected on Tolstoi and Zapadni and burned (Jordan 1922:585). In the same year, large boulders were placed in rows on the sand flats at Zapadni for pups to climb on. A theory was then held that hookworm infestation is correlated with sandy "death traps."

7) Lucas (1899c, part 3, p. 59-68, 4 pls.) tabulated the food items found in stomachs of 409 seals taken in Alaskan waters. He also described the contents of pup and bachelor stomachs examined on land. His information was largely based on the reports of Townsend (1898, part 4, p. 472), and in Murray (1898b, vol. 2, p. 52) and of Alexander (1892[8], 1898:600). Lucas (1899c:62) mentioned also a food habits study by Merriam, the results of which were evidently not published. (Townsend had been the first naturalist to obtain evidence of food habits when, on 2 August 1892, on the deck of the *Corwin*, he opened the stomachs of 33 seals.)

8) The methods and results of pelagic sealing were summed up by Townsend (1899:223), at a time when about 100,000 seals were being killed annually at sea. Data on the distribution and migration of seals, obtained during the peak of pelagic sealing, will perhaps never again be surpassed in volume, though certainly in refinement of detail. Townsend's (1899, opp. p. 234) map, based on a total take of 304,713 seals from 1883 to 1897, showed the position of sealing vessels in all months of the year except October and November. The suggestion is often heard that pelagic sealing was, and could be again, a practical method of harvesting fur seals. But Townsend gave counter arguments, among them the difficulty of law enforcement, the unreliable statistics of the kill, the waste through buck-shot-riddled skins, the loss of seals by wounding and sinking, the inhumanity of pups starving on land, and the hazard to men and ships.

9) The first attempt to mark seals by hot-iron branding was conducted by Murray (a cattleman from Colorado) on North Rookery in August 1896. Totals of 337 female pups and 11 female adults were branded in 1896 and 7,251 female pups and 118 female adults in 1897 (U.S. Treasury 1898:38-39, 1898-99, part 2, p. 447; Jordan and Clark 1899: 326, 328). The purpose was to deliberately scar the pelts in order to make them unattractive to pelagic sealers. The program was continued through 1902 on St. Paul and 1903 on St. George. We believe that no adults were branded after 1897. A nearly complete record of the female pups, numbering at least 22,833 branded from 1896 to 1903, was compiled by Hanna (1921b:111). Strangely, no one seems to have recognized the value of the branded seals as specimens of known age. Had there been a biologist on the Pribilofs from 1898 to 1905, he would have identified and described the yearling fur seal, and thereby provided the Government with scientific information it sorely lacked. The 1913 controversy between the Government and Elliott over identification of "yearlings" will be mentioned later.

10) In addition to branding, a second experiment designed to discourage pelagic sealing was carried out in 1896-97 (U.S. Treasury 1898-99, part 2, p. 419-421, 461, 588-592; Jordan and Clark 1899:329). The plan was to round up large numbers of bachelors after the close of the sealing season, to hold them for a month in a corral, and to release them in autumn when the pelagic sealers were leaving the Bering Sea. Conceived in desperation, the plan did not give birth to a management system. About 950 seals were corralled in Salt Lagoon on 17 August 1896. The Aleuts who guarded them had a lively time, some running along the beaches, shouting; one in a boat in mid-channel at the outlet of the lagoon. On 4 September about 3,000 seals were again held for a day in the lagoon. The next year, 300 acres of the lagoon were enclosed with 50-in (?) wire fence and about 750 seals were held during the first week of September. We suppose that the ideas of Murray, the cattleman, led to the corralling experiment.

11) On 19 August 1896, the sex ratio of pups on Gorbatch Rookery was found to be 246 males, 212 females (U.S. Treasury 1898-99, part 2, p. 423). Many years later, on 4 August 1950, Kenyon and Scheffer repeated the study, finding 505 males, 495 females (Kenyon et al. 1954:19).

12) Jordan and Clark (1898a:45) gave the specific name *alascanus* to the Pribilof seals on account of the "slight, [though] permanent and constant" differences from Asian seals. The name stuck until Stejneger (1936:278, 285) pointed out that it was preoccupied by Walbaum's 1792 name *cynocephalus*. Finally, Wilke (1951:10-22) showed that Asian and North American seals cannot be told apart on anatomical grounds, and the name *ursinus* for the northern fur seal came again into use.

Incidentally, the investigators noted a "barnacle covered cow" at Northeast Point (U.S. Treasury 1898-99, part 2, p. 507). Gooseneck barnacles are not uncommonly seen attached to the pelage of seals. Scheffer (1962:40) found *Lepas hillii*; Fiscus et al. (1964:57) found *L. pectinata* and *L. anatifera*.

The investigations of 1896-97 did not quite result in an international treaty to stop pelagic sealing. In December 1897, signatures of the United States, Japan, and Russia were obtained, but not of Great Britain (representing Canada). Canada held out for a share of the Pribilof harvest, a share which she finally obtained in 1911 (Jordan 1922:602). "As the investigators had no international status, and were not empowered to negotiate a settlement, their labors now came to an end. The matter [of pelagic sealing] was placed in the hands of a Joint High Commission of the two nations sitting at Quebec in 1898. This Commission had other matters of difference to settle, and in the conflict of interests the fur-seal question still remains in status quo" (Marsh 1907:461).

No scientific studies were made from 1898 to 1903, inclusive. Walter Irwin Lembkey was agent in charge from 1898 or 1899 to 30 June 1913, during the years when the seal herd was declining to its lowest level in history (U.S. Congress, House 1911:9; Lembkey 1914:140). He made routine counts of seals but was opposed to exploratory research, as we will show.

Townsend visited the islands in 1900. "On his last visit he said it was useless for him to make the trip, as the Treasury agents could gather the information desired, and he availed

[8]Alexander, A. B. 1892. Manuscript report concerning fur seals, 1892. The National Archives, Records of the U.S. Fish Comm., Record Group 22, 40 p. and 1 photograph. [Photocopy seen.]

himself of the data in their possession" (Judge, *in* U.S. Congress, House 1911, Appendix A, p. 664).

On 9 July 1899 the E. H. Harriman expedition, including many scientists, stopped at St. Paul Island. Here "an opportunity was afforded of studying these interesting breeding-grounds of the fur-seal" (Kincaid 1901:73). Apparently the party stayed only 1 d (Hultén 1940:316).

The Department of Commerce and Labor was created by an act approved 14 February 1903 (32 Stat. 828). On 1 July 1903 the "Alaskan Fur-Seal Service" was transferred from the Treasury Department to the new department where it was placed under the immediate direction of the chief clerk, Frank H. Hitchcock. Also on 1 July 1903 the Bureau of Fisheries was created out of the old Fish Commission which had been an independent agency of the Government from its start in 1871. The fur seal service was not, however, immediately placed in the Bureau. David Starr Jordan urged in December 1905 that this be done. In a letter of 28 December 1908, the Secretary of Commerce and Labor issued intradepartmental orders and the transfer was effected. From 1908 to the present, fur seal matters have been the responsibility of a federal fishery agency under one name or another. George M. Bowers, Commissioner, Bureau of Fisheries, created on 12 January 1909 a "Fur-Seal Board" of five employees: Evermann, Lembkey, Marsh, Judge, and Alexander; also an "advisory board" of six nonemployees: Jordan, Stejneger, Merriam, Sims, Lucas, and Townsend. (The foregoing history is from U.S. Congress, House 1911, Appendix A, p. 5, 662-667, 689, 811; from Sater 1960:4-5; and from Evermann and Chamberlain 1912:5.)

Early in 1904, resolutions had been introduced in both houses of Congress calling for the suspension altogether of sealing on the Pribilofs (U.S. Congress, House 1904:57). Behind them lay the "Elliott campaign" (U.S. Congress, House 1904:47) against the North American Commercial Company. As a result, the Secretary of Commerce and Labor called on 1 May 1904 for renewed studies of the fur seal herd and for tighter management methods (U.S. Congress, House 1904:35-43). He issued the "Hitchcock regulations," informally so-called because they had been drafted by his chief clerk. Hitchcock was especially interested in fur seals; he had been an assistant to Merriam in 1891 (Hitchcock 1904:52).

During the season of 1904, over 2,000 bachelors were marked for the "breeding reserve," some by hot iron and some by clippers (U.S. Congress, House 1904:45, 61-62, 128). Nearly all skins taken were weighed in fresh condition (U.S. Congress, House 1904:91-92). The rookeries were to have been photographed with two new "Carlton" cameras 8×10 in (20×25cm), but the cameras did not arrive in time (U.S. Congress, House 1904:48, 51). All rookeries, however, were photographed in 1905 and some in 1906 from the camera stations of 1892-97 (Lembkey 1908:33; Marsh 1911:361) (Fig. 3 top). All of the 1904 studies were supervised by Lembkey, agent in charge of seal fisheries.

Throughout U.S. ownership of the Pribilofs, sealing managers have tried with varying effort to take seals of selected kinds. They have concentrated on the 2-, 3-, and 4-yr males, and the fur market has developed on the basis of skins from animals of these ages. Until 1913, however, the managers had no way of knowing the true age of a seal. They killed for size, and a measure of their judgement was disclosed later when the salted skins were graded for size in London. By 1892, and probably earlier, records were being kept in London, not only of grades but also of weights of the salted skins (U.S. Congress, Senate 1895, part 8, p. 917).

Some control, based on fresh skin weight, of the sizes of seals killed was evidently in effect through the lease years. The record is not clear; it does not show whether the control was imposed by the Government or by the lessees. Daniel Webster was continuously in charge of local killings for at least 24 yr, from 1868 to at least 1892. He stated in 1892 that "until 1887 or 1888. . .the decrease [due to pelagic sealing] was not felt in obtaining skins, at which time the standard was lowered from 6 and 7 pounds to 5 and 4½ pounds" (U.S. Congress, Senate 1896a, part 1, p. 148). This means, we believe, that the minimum size was reduced to 4.5 lb (2.0 kg) for summer-taken skins and 5 lb (2.3 kg) for fall-taken skins.

We find later, however, that "previous to 1904 no restriction upon the size of bachelors to be killed was enforced" [Lembkey 1910(1911):758] (Fig. 4 top). Starting with the season of 1904, the lessees were ordered to kill deliberately no seals, the "green" (fresh) skins of which were < 5.5 lb (2.5 kg) or more than 8.5 lb (3.9 kg) in weight. From 1906 to 1911, inclusive, the limits were 5 and 8.5 lb (2.3 and 3.9 kg). (The leasing system was abandoned at the end of 1909.) From 1904 to 1911 the Pribilof manager was required not only to kill prescribed sizes of males, but to submit for publication at the end of the season a distribution list of the weights of all skins taken (U.S. Congress, Senate 1908:37; U.S. Congress, House 1911, Appendix A, p. 758, 1185; Lembkey 1912:98).

From 1904 to 1923, though not in each year, it was the custom to mark a specific number of bachelor seals before, during, or following the killing season. The operation was referred to as "shearing," "clipping," or "branding," though it meant clipping, with sheepshears, a round patch of the pelage from the top of the head. (Hot-iron branding of bachelors was tried but abandoned midway through the season of 1904; it was resumed in 1923.) Shearing was done to reassure the public that an adequate breeding reserve was being spared (Lembkey 1912:94; Scheffer 1950d:7). Today, adequate escapement of males is insured through population studies and controlled harvests. Up to the 1950's, one could still occasionally find near the killing fields a weathered wooden yoke which had been used to hold the bachelor's neck to the ground during the shearing operation.

In 1904, the Museum of the Brooklyn Institute of Arts and Sciences was cautiously granted permission to secure "for scientific purposes six skins of fur seals meeting death through accident" on the Pribilof Islands, though the scientific collector of the museum was not permitted to visit the islands (U.S. Congress, House 1911, Appendix A, p. 43).

The annual bull count was established as routine in 1904. A manuscript in the Marine Mammal Biological Laboratory (file 7.04.01) entitled "Fur Seal Data, 1896-1908" shows annual bull counts by rookeries. Complete counts were made in 1896, 1897, 1899, and in 1904-08. Partial counts were made in the other years.

In a letter dated 16 January 1906, David Starr Jordan wrote to the President urging that a naturalist be appointed to the Pribilofs. He reiterated that "the fur-seal question is now chiefly, almost wholly, biological" (U.S. Congress, House 1911, Appendix A, p. 328). Official reports from the islands indicated that no adequate study was being made of hookworm, changes in harem areas, the bull-to-cow ratio, and other biological matters. "In recommending the transfer of

the fur-seal matter to the Bureau of Fisheries [from its independent status under the Secretary] I had in mind the fact that this bureau could provide the scientific inspection and control necessary" (U.S. Congress, House 1911, Appendix A, p. 332).

Agent Lembkey countered Jordan's suggestion with a long letter giving the history of the Pribilof Islands and the scientific work done thereupon up to 1900, the last year that Townsend was on the islands. Lembkey developed the argument that "in matters pertaining to seal life practical experience is often of greater importance than abstract biological knowledge" (U.S. Congress, House 1911, Appendix A, p. 339). His assistant, James Judge, concurred, pointing out that "the naturalists, according to their own statements, have already exhausted the scientific features of seal life" (U.S. Congress, House 1911, Appendix A, p. 663).

Nevertheless, Millard C. Marsh, whom we may regard as the first "fur seal biologist," was assigned to the Pribilofs in 1906. His main duties as outlined in a letter dated 28 April 1906 were to "census" the seal population and to investigate pup mortality (U.S. Congress, House 1911, Appendix A, p. 347-348). He arrived at St. George Island on 8 June 1906 and soon after reported to Barton Warren Evermann, "In Charge, Scientific Inquiry, Bureau of Fisheries" (Marsh 1911). In 1907 Marsh published a popular account of the seal herd and its problems.

During Marsh's first summer on the islands he found no hookworms, though he evidently looked at no more than a dozen pups. He sketched the harem outlines for most of the rookeries and photographed on Ardiguen and Kitovi. He recorded fur seal body temperatures (Marsh 1911:364). He assisted in the counting of harem bulls on both islands. The count-

Figure 3.—Top: Kitovi Amphitheater when the seal herd was near its all-time low, photographed by Walter I. Lembkey between 14 and 18 July 1905 from "Station 13" (photo by V. B. Scheffer). Bottom: "Watch House and Native Guard, St. Paul Island" is the caption on this 1905 photograph by Walter I. Lembkey. Some of these men killed five Japanese poachers at Northeast Point in 1906 (photo by V. B. Scheffer).

ing of pups was interrupted when pelagic sealers appeared offshore. In order not to frighten the rookery animals into firing range of the sealers, the Government forbade all visits to the rookeries. Five poachers were killed on St. Paul beaches on 17 July (Sims 1906:15-19) (Fig. 3 bottom). Marsh recommended that virtually all matters pertaining to fur seal management be turned over in the future to naturalists (Marsh 1911:366). In critical review, Marsh's efforts in 1906 were spread thinly and generally unsatisfactory.

In the summer of 1906, Edwin W. Sims, Solicitor of the Department of Commerce and Labor, spent a week on St. Paul Island. He subsequently made a report which is especially valuable because it contains statistics of the seal herd from 1786 to 1906 (Sims 1906, tables 1-5).

On 1 July 1908, Capt. A. W. Baber, of Seattle, took motion pictures at Gorbatch Rookery which he showed in a "biograph exhibition" at the "Eskimo village" concession of the Alaska-Yukon-Pacific Exposition in 1909. These were undoubtedly the first motion pictures of fur seals (U.S. Congress, House 1911, Appendix A, p. 583-584, 628). The famed explorer, Roy Chapman Andrews, filmed the seals of St. Paul in the belief that, before his visit in the summer of 1913, "no one with a movie camera had been allowed on the islands" (Andrews 1929:183).

Japanese and Caucasians on Japanese schooners, continued recklessly to hunt seals in the coastal waters of the Pribilofs. It is difficult now to imagine the tension under which the administrators and scientists on the islands must have lived in the last years of pelagic sealing. In 1908 "the watchmen on guard at Northeast Point reported on half a dozen occasions that they had observed the small boats from the schooners to form a line a mile or so in length and, in that formation, advance abreast on the rookery. When close to shore, the occupants of the boats would begin a fusillade with their shotguns, the noise of which would drive off a number of seals from the rookeries and hauling grounds. The boats would then withdraw a safe

Figure 4.—Top: "Seal Killing about 1900, St. Paul Island" is the caption on an 8x10-in glass plate; photographer unknown. The scene is near Village Pond, where seals used to be driven from the Reef (photo by V. B. Scheffer). Bottom: G. Dallas Hanna in his laboratory at St. Paul, 1915; self-portrait (photo by V. B. Scheffer).

distance from shore and there pursue and seek to capture those seals which had just been driven off the land by them" (U.S. Congress, House 1911, Appendix A, p. 607).

In 1908 "no attempt was made. . .to count pups on any of the rookeries for the reason that during the latter part of July and early August hardly a day passed that there were not one or more Japanese sealers operating off the rookeries. Under the circumstances both Maj. Clark and myself deemed it to the best interest of the seal herd not to subject the rookeries to the great disturbance necessary in pup counting" (Lembkey 1911b:648). Ezra Clark was agent of St. George Island from about 1906 to 1908.

Pelagic sealing was wasteful exploitation of a resource at sea and it encouraged overkilling on land. Wrote the Pribilof agent in 1907 "unless this settlement [of the pelagic sealing question] on a satisfactory basis appears imminent, I would recommend the killing on land of every seal that can be killed under existing law" (Lembkey 1908:14).

By intradepartmental order of 28 December 1908, the Secretary of Commerce and Labor assigned to the Commissioner of Fisheries, Bureau of Fisheries, the administration of the Pribilof Islands and the fur seal industry. The Bureau started in early 1909 to assemble an elaborate card file of information on every aspect of the islands, their natural history and their human history (U.S. Congress, House 1911, Appendix A, p. 703). It was classified in 22 subjects. We do not know how long it was maintained.

In the summer of 1909, George A. Clark returned to the islands as a special assistant to take a fur seal "census" as he had done in 1897. He found that during the 12-yr period the total herd had shrunk to only one-third of its 1897 size. He estimated that 6,000 pups, or 8.3% of those born, had died of starvation in 1909. These shocking facts were sent to the State Department with a view to the renewal of efforts for an international agreement (Clark 1911).

During the summer of 1909, Clark preserved bits of testes from a 3-yr-old and an 8-yr-old seal, probably at the request of Frank M. MacFarland, of Stanford University. The specimens were later studied by Oliver (1913) and Starks (1928). (Dorothy Starks was daughter of the famed ichthyologist, Edwin C. Starks.) Starks (1928:490) was first to report on the chromosome number of fur seals "diploid number of 28 plus 2, and a haploid of 14 plus X or Y."

The first successful experiment in weaning silver pups was carried out in 1909-10 by boatswain Thurber on board the revenue cutter *Bear* (U.S. Congress, House 1911, Appendix A, p. 728-732; Evermann 1911). Two pups, "Bismark" and "Mamie," were captured on St. Paul Island on 8 and 9 October 1909. They were fed at first on "evaporated cream mixed with bits of fish," later on fish alone. They were eventually delivered by boat and rail to the Bureau of Fisheries Aquarium in Washington, D.C., in January 1910. Here they died in 1918 (Bower 1919:99).

On 7 October 1909, "small threadlike worms found in the trachea of a pup from the Reef" were saved by James Judge (U.S. Congress, House 1911, Appendix A, p. 1173). These became the type specimens of *Orthohalarachne attenuata* (Banks) 1910 (originally described as *Halarachne attenuata*), one of two species of nasal mites known from the fur seal (Newell 1947: 250).

Evermann proposed on 24 February 1910 that Thurber be hired for the summer to raise 20 pups in a nursery at Unalaska. "These pups would have a considerable commercial value, and could easily be disposed of at a price sufficient to more than offset the cost of raising. Having domesticated a number of these pups, it is suggested that overtures be made to the British Government with the object of furnishing the Canadian Government with enough pups to start a rookery of their own on the Atlantic coast" (U.S. Congress, House 1911, Appendix A, p. 934).

Late in 1909, when the North American Commercial Company had taken its last quota of skins, the question of re-leasing the 20-yr sealing right became critical. A Senate resolution introduced in December, backed by Elliott and the Camp-Fire Club, called for the abolition of the leasing system, for a 10-yr closed season on land killing, and for revision of the Paris regulations (U.S. Congress, House 1911, Appendix A, p. 736). The Bureau of Fisheries countered with a proposal that the leasing system be perpetuated, though with the Government in control of virtually all activities on the islands. (At that time, the Company owned much of the property on the islands, including the homes of the Aleuts.) Jordan, however, hoped that the Government would "not under any circumstances lease the products of the islands, at least in such form as has been in vogue for the past 40 years" (U.S. Congress, House 1911, Appendix A, p. 813).

Executive Order 1044, dated 27 February 1909, set aside Walrus and Otter Islands as a bird reservation to be known as the Pribilof Reservation. The Bureau, on 15 April 1909, appointed James Judge "a warden to have immediate supervision. . .of all matters pertaining to the birds not only of the reservation but of the entire Pribilof group" (U.S. Congress, House 1911, Appendix A, p. 904). Judge's first report was dated 12 October 1909. It is interesting to read that on three visits to Walrus Island in June and September he saw only one live northern sea lion, *Eumetopias jubatus*, where today there are thousands. In the following year, all of the Pribilofs were declared a special reservation. Judge was continued as warden under the new chief naturalist, Hahn (U.S. Congress, House 1911, Appendix A, p. 983).

THE TRANSITION YEARS, 1910-11

This important "act [36 Stat. 326 (1910)] to protect the seal fisheries of Alaska, and for other purposes" was approved on 21 April 1910, effective 1 May 1910 (U.S. Congress, House 1911, Appendix A, p. 941). It continued the ban on pelagic sealing by U.S. nationals and the ban on killing females and pups on land. It declared the Pribilofs a special reservation for government purposes. Most important, it did away with the leasing system and made the Secretary of Commerce and Labor directly responsible for the Pribilof Islands and the fur seal industry. When the lease of the North American Commercial Company expired on 1 May 1910, the Government took control of sealing and has held it ever since. During 1910 and 1911, though pelagic sealing was being carried on by Canadians and Japanese, a treaty designed to prevent it was taking shape. The fur seal population was still declining.

In 1907, Elliott had turned for help to William T. Hornaday, director of the New York Zoo and director of the Camp-Fire Club of America. From then until 1911, when the Fur Seal Treaty was signed, there ensued "one of the longest, dirtiest political battles America had known" (Martin 1946a:238). To Hornaday and his allies in the Camp-Fire Club much credit is

due for arousing public interest in the plight of the fur seals, for ending the contract system, and for ending pelagic sealing (Hornaday 1920, 1931; Martin 1946a:237-246).

The Bureau of Fisheries, hopeful in 1910 that Government control of sealing could begin on a firm scientific basis, resolved to employ a permanent naturalist. Until one could be found, Harold Heath, professor of zoology at Stanford University, was given a temporary appointment. He arrived at St. Paul Island in June 1910 and returned in the summers of 1917 and 1918 (U.S. Congress, House 1911, Appendix A, p. 972, 1209; Heath 1911; Preble and McAtee 1923:125). He made a relief map of St. Paul. In 1918 he fell from Tolstoi Point and suffered fractures of both legs and several face bones.

On 24 August 1910, Walter Louis Hahn, formerly head of the biology department at South Dakota State Normal School, arrived at St. Paul Island to be permanent naturalist. He was to "have charge of all matters pertaining to the investigation, study, and management of the fur-seal herd, the blue foxes, and all other life on the islands" and to "give advice to the agent in charge regarding the number of seals and foxes to be killed each season" (U.S. Congress, House 1911, Appendix A, p. 978). His duties were to survey the possibility of introducing reindeer, sheep, poultry, muskrats, mussels, crawfish, mink, otter, water lilies, and other useful animals and plants; also to experiment in the artificial rearing of fur seal pups (U.S. Congress, House 1911, Appendix A, p. 981-987). Hahn converted a native house into the first biological laboratory (Hanna footnote 7, p. 5). He was to have collected in 1911 some "material from at least two young male seals" for shipment to "H. Dexler" (undoubtedly the noted German anatomist) (U.S. Congress, House 1911, Appendix A, p. 1008). Unfortunately, Hahn drowned in Village Lagoon on 31 May 1911.

During the sealing season of 1910, the first in 40 yr under Government control, the Pribilof agent was busy in explaining the new regime to the Aleuts, in arranging to purchase the North American Commercial Company's property on the islands, and other administrative matters. Reports by Lembkey (1911c) and Heath (1911) indicate that little but routine biological information was obtained. Attempts were made to raise several dozen pups, some black and some silver, by force feeding them milk, small fish, salt salmon, and (!) mutton broth. Pups placed in a tank on 15 September ate at once some small tidepool fishes (*Liparis* sp.?) and chopped sculpin. Does this suggest that small inshore fishes may be their natural food at weaning time? Ten silver pups were sent to Seattle on the *Bear* (Lembkey 1911c:1032).

Heath recommended that "a museum be installed on the islands, containing, so far as is practical, specimens of all the animals and plants. And equally desirable is a library, comprising all works that in any way are concerned with the biology of the country" (Heath 1911:1224). Subsequent events have shown that Pribilof research materials are safer in well-curated institutions in the continental United States.

A graph showing the "land and pelagic catch of Pribilof Islands fur seals, and average London prices of salted raw skins, 1870-1910" was given by Tomasevich (1943:79).

In 1911, when the seal population was at its lowest level in history, 1,356 harem bulls were counted, or one-eighth those counted in 1964 (Lembkey 1912:99). An estimate of the total herd, 123,600 seals, made in 1911, was probably low, for an estimate made the following year upon more reliable data was 75% higher.

After the death of Hahn in 1911, Millard C. Marsh, pathologist of the Bureau of Fisheries, was appointed chief naturalist of the Pribilofs. He had spent the summer of 1906 on the islands and he returned on 23 August 1911 (Evermann 1913: 9-10; Preble and McAtee 1923:3).

On 7 July 1911 a treaty which was to endure for 30 yr was signed by representatives of the United States, Great Britain (on behalf of Canada), Russia, and Japan. It became effective on 15 December 1911 (U.S. Congress, House 1912). It had no formal name but was referred to as "the convention. . .for the preservation and protection of the fur seals and sea otter which frequent the waters of the north Pacific Ocean" (U.S. Congress, House 1912:3). Article 1 of the convention prohibited citizens and subjects of the contracting parties from engaging in pelagic sealing north of the 30th parallel in the North Pacific Ocean, and Bering, Kamchatka, Okhotsk, and Japan Seas. In Article 2, the contracting parties agreed that no person or vessel engaged in any way with pelagic sealing could use their harbors or ports. In Article 3, the contracting parties prevented the importation of North Pacific sealskins into their respective territories except those officially taken on the breeding grounds. Article 4, permitted the taking of seals by Indians, Ainos, Aleuts, or other aborigines from canoes, not transported by other vessels, and propelled entirely by oars, paddles, or sails and without use of firearms. Other Articles of the convention dealt with enforcement of the treaty, and apportionment of the harvest from the breeding islands. The sea otter also received protection under the treaty. The convention effectively put an end to pelagic sealing and was instrumental in leading to the recovery of the herds.

THE PERIOD OF POPULATION RECOVERY, 1912-39

When Congress, on 24 August 1912, passed a law (37 Stat. 499) giving effect to the treaty, it also declared a closed season on commercial sealing on the Pribilof Islands for 5 yr. The law had been anticipated by the Bureau of Fisheries; no seals were killed commercially in the summer of 1912, even before the law went into effect. The kill through the summer season ending 11 August 1912 was only 2,427 (Evermann 1913:83). The closed season was regarded by Evermann (1919:281) as an error in judgement. "There was only one man [Elliott] who had ever been to the seal islands who advocated a close season and the large reservation of males, and his purpose was *not* the preservation of the fur-seal herd. Every naturalist in America who was familiar with the habits of the fur seal strongly protested against both measures." Clark (1913) concurred.

As the year 1912 opened, the fur seal herd was freed from a 30-yr drain upon its breeding stock, especially upon the female element of the stock. "It became important therefore to know the exact status of the herd and a full count of the pups was undertaken and successfully accomplished by the writer" (Clark 1912:896). Clark had helped with the partial counts of 1896-97 and 1909.

In 1912 he counted 70,035 pups on St. Paul and 11,949 on St. George, a total of 81,984. (When the herd finally recovered, about 1940, the annual pup recruitment had risen to about 530,000 (Kenyon et al. 1954:1).) For 5 successive years, 1912-16, and in 1922, all pups on the Pribilofs were counted. After 1922, the task became too difficult; it was never repeated.

Pelagic sealing had brought death by starvation to thousands of orphan pups on the islands. Now, in the absence of pelagic sealing, Marsh began in 1912 to study mortality factors at the beginning of the new regime. The loss of pups in 1896 had been estimated at 7.0% before the 10th of August, presumably of "natural" causes before starvation became effective, and at 13.5% through the entire summer and fall (Jordan and Clark 1898a:95, 214). The early losses in 1908 and 1909 (on St. Paul Island only) had been estimated at 7.2 and 8.3%, respectively (Lembkey 1910:40-41). In 1912, however, Marsh found a "total natural loss" up to 22 August on St. Paul Island of only 1.25% (Marsh 1912:897). Never again during the period of recovery of the herd was the mortality of pups on land to rise about 3.0% (Kenyon et al. 1954:30). We are unable to explain the high mortality rate in early summer while pelagic sealing was in effect, as compared with the low rate when it had ceased.

Marsh also found "typical cases of asphyxia neonatorum, or suffocation of the new born, a hitherto unidentified fatality" (Marsh 1912:898). He believed that 18% of the pup deaths before mid-August could be ascribed to this cause.

After the discovery of *Uncinaria lucasi* in 1897, no serious effort was made to look for it until 1912, when Marsh found it in 17 out of 175 pups (Marsh 1912:897). Agent Lembkey stated flatly that "*Uncinaria* has not now, nor has had for several years past, any known existence on the islands" (Lembkey 1908:26). Heath stated that "very few cases [1 out of 2 pups examined] were noted by Dr. Chichester in 1909, and not one was detected [in 1910]" (Heath 1911:1223). In the light of modern knowledge, it is significant to read a statement of Marsh in 1906 "*Uncinaria* has been found by Dr. C. W. Stiles in dead seal pups born in the zoological park of parents from the Pribilof Islands. The parasite is not *uncinaria lucasi*, that of the seal, but another form" (Marsh 1911:363).

Also in 1912, a special study was made of the dimensions and weights of sealskins on the killing fields and in the salt kench (Lembkey 1913:85-95). Agents Lembkey and Clark, and naturalist Marsh, carried out the study. The objective was to convince "others that the work of the sealers is in conformity with [age] regulations" (Lembkey 1913:91). It was a fuzzy objective, for although the regulations specified a minimum age limit for killing, no one in 1912 knew how to identify age.

This shortcoming was realized, and in the fall of 1912 fur seals were first marked for scientific purposes. On 5,529 pups, the letter "T" was hot-iron branded on top of the head (Lembkey 1913:96).

The following year, the return of branded yearlings was awaited with keen interest. How many were seen, and when they were seen, is not clear from the record. The statements of Lembkey (1914:158-159), Osgood et al. (1915:60-64), and Clark (U.S. Congress, Senate 1926:41) do not agree. Thirteen years later, Elliott was still making political capital of the discrepancy. Sufficient to say, about 80 to 90 branded yearlings, some representing repeat observations, had been seen through 25 November 1913, none earlier than 10 July. The fact that many or most yearlings do not return to land but remain at sea became known for the first time.

Only three yearlings were reported killed (Bower and Aller 1917:98). Eventually, several hundred branded seals of the class of 1912 were killed and recovered, the oldest being a 10-yr-old male in 1922 (Bower 1923:91).

Marsh resigned as naturalist in late 1912 or early 1913. He was succeeded by F. M. Chamberlain. Effective 30 June 1913, Congress abolished the position of Pribilof agent and "F. M. Chamberlain, naturalist. . .succeeded to the administrative charge of all affairs on the islands" (Lembkey 1914:140). He arrived at St. Paul on 13 July 1913 (Evermann 1914:10). According to Andrews (1929:194), Chamberlain was "sick unto death with tuberculosis." He left the islands on the last revenue cutter of the winter of 1913-14.

In July 1913, G. Dallas Hanna arrived at St. Paul as a schoolteacher (Fig. 4 bottom). He remained almost continuously until September 1918 and returned in the summers of 1919 and 1920 (Preble and McAtee 1923:4). He returned briefly in 1960 (Hanna footnote 7). He was keen to learn about nature, and his duties as schoolteacher and storekeeper did not keep him from collecting specimens, photographing, and assisting with research on fur seals in the first decade of direct Government control of sealing. His contributions to knowledge of the Pribilofs are represented by 41 publications which appeared from 1914 to 1951 (Miller 1962).

In 1913, Elliott was appointed as "duly qualified expert" and special agent of a congressional committee (Elliott and Gallagher 1913). He visited St. Paul Island in July 1913 to obtain "facts which bear upon the commercial ruin and near extinction of our fur-seal herd of Alaska" (Elliott 1913:3). On this visit, he made no scientific studies. The printed minutes of the committee hearings, together with statements inserted by Elliott in the record, amounted to 400 pages. His visit was not mentioned in the annual report of the Alaska Fur-Seal Service for 1913.

According to Hanna (1923:47)[9] "Elliott and an assistant were sent to the islands in 1913 in an irregular manner and the House of Representatives refused to allow their expenses and compensation. Rothermel lost his seat in Congress and narrowly escaped being expelled before the expiration of his term." John H. Rothermel was sponsor of the Elliott-Gallagher trip to the Pribilofs, and Chairman of the Committee on Expenditures in the Department of Commerce, House of Representatives.

Secretary of Commerce Redfield now felt that administration of the Pribilofs was getting out of hand (Elliott and Gallagher 1913:3-5). He especially did not approve of Barton W. Evermann speaking, as a biologist, against the Government's closed season on the cropping of seals. In 1914 Redfield removed jurisdiction for the Fur-Seal Service from the Division of Alaska Fisheries and placed it under Deputy Commissioner of Fisheries E. Lester Jones. Jones visited the Pribilofs in summer of 1914 and recommended that the Government spend substantially more in improvements there (Jones 1915:140). "As a result of voluntary resignations [including, we suppose, Lembkey and Evermann]. . .there was a considerable reorganization of the personnel and methods" (Bower and Aller 1915:67). Ward T. Bower, Agent, assumed responsibility for the Fur-Seal Service, a burden which he was to carry until 1947. The position of naturalist, last held by F. M. Chamberlain in 1913, was abolished.

[9]Hanna, G.D. 1923. The Alaska fur seal islands. Unpubl. manuscr., 249 p. Intended by Hanna to be published as a semipopular book; donated by him in 1941 to the U.S. Fish and Wildlife Service. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Between 1913 and 1922 the Government developed a new method for processing and selling Alaskan sealskins in the United States. The 1912 catch had been sold in London on 17 January 1913 (Evermann 1913:10). The 1913 catch was sold in St. Louis by Funsten Brothers and Company on 16 December 1913, representing the first American sale (Evermann 1914:10). The combined catches of 1914 and 1915 were sold by Funsten on 21 October 1915 (Bower and Aller 1917:106). In 1915 the Department of Commerce entered into contract with Funsten to process as well as to sell sealskins (Bower and Aller 1917:107; Martin 1946a:251).

Processing began at St. Louis in December 1915. The first sale in the United States of processed (as against salted) sealskins was held in St. Louis on 20 December 1916. The Funsten firm went bankrupt in 1920, following a severe depression in the fur market. On 15 February 1921, the Department of Commerce cancelled its contract with Funsten and negotiated a new one for 10 yr with the Fouke Fur Company (U.S. Congress, Senate 1923:2-6). When Fouke took over from Funsten they received 57,612 skins then in custody of Funsten (Bower 1922:71).

P. B. Fouke had been a guiding spirit in the Funsten firm. "Colonel" Fouke lured two sealskin technicians from Rice and Brothers of London but was subsequently enjoined from using their secret dye formula; he then developed his own. While three sales were held in 1912 (Bower 1922:71), we believe that the first sale of skins, processed, or mainly processed, by Fouke, was one held in St. Louis on 3 April 1922 (Bower 1923:96).

Of human interest is the fact that during the 1911 treaty negotiations, Ernest Poland, member of a London firm which then led the world in the processing of seal skins, was adviser to the British Ambassador. He suggested that the treaty be worded in such a way as to favor the London Public Fur Auction. This was not done "When [he] returned from America he was furious and said it was the end of the Fur Seal trade in London" [reported by his son, Rex Poland (1964:22)]. The elder Poland was prophetic; 2 yr later the last sale in London of American skins was held.

The Osgood, Preble, and Parker Study, 1914

The Secretary of Commerce on 26 May 1914 appointed a commission of three eminent zoologists to visit the seal islands. He wrote: "You have been selected for this service because, not having previously been identified with or in any way concerned with fur seals or the fur-seal controversy, it is expected that your observations and conclusions will be uninfluenced by past contentions but will depend wholly on the existing conditions" (Osgood et al. 1915:14).

The Secretary's appointees were: George H. Parker of Harvard University, Wilfred H. Osgood of the Field (Chicago) Museum of Natural History, and Edward A. Preble of the Bureau of Biological Survey. The three had been nominated by the National Academy of Sciences, the Smithsonian Institution, and the Department of Agriculture, respectively. "Shortly after the organization of the group we met in Washington with Mr. W. C. Redfield, secretary of the Department of Commerce, for a general conference. The outcome of this meeting was a request. . .that he wished a report returned by us which we all could agree upon, and not a split report with each one expressing his own views. As our report was to turn mainly on an enumeration of seals it seemed to me that the secretary's admonition savored rather of politics than of scientific integrity, for we all three entertained no doubts about our ability to count and to tell the truth" (Parker 1946:150-151). The Canadian Government also sent scientists James M. Macoun, who had been on the islands in 1891, and B. W. Harmon of the Dominion Department of Marine and Fisheries. We find no record of a published report from either. The Japanese Government sent its first observer to the Pribilofs, T. Kitahara of the Imperial Fisheries Bureau.

The work assignment of Osgood, Preble, and Parker was staggering. It was to "census" the Pribilof herd by age and sex components, to evaluate past influences upon it, to evaluate current sealing methods, and to recommend future practices which would lead to restoration of the herd. Other assignments included study of the welfare of the native peoples, the taking of motion pictures for publicity use, and studies of foxes, reindeer, and birds (Osgood et al. 1915:14). The field work was completed between 21 June and 30 August 1914. The more important scientific accomplishments are listed below.

1) Contour maps representing each of the 22 rookeries and showing the approximate locations of harems were printed. "Before the investigation of 1914 was begun it was found that unpublished charts showing the number and approximate position of the harems on each rookery had been made in 1912 and again in 1913 by Special Investigator G. A. Clark. These charts showed the contours of the topography as surveyed by the United States Coast and Geodetic Survey [in 1897] and also indicated the position of the rocks on which conspicuous numbers were painted at the time of the survey" (Osgood et al. 1915:27). Maps no. 23 (St. Paul Island) and no. 24 (St. George Island), showing the location of individual rookeries, were the first to be published since the crude maps of Elliott (1882, frontispieces).

2) A method of computing the number of seals in certain age classes, and of computing total herd size, was established (Osgood et al. 1915:37-38). Essentially the same method was followed by Bureau of Fisheries officials until the late 1940's. It was originally based on hard facts: the number of pups counted, the number of bulls counted, (Fig. 5) and the number of bachelors killed or reserved. The investigators stressed the importance of continuing the pup counts in future years to obtain the best possible estimate of the rate of increase of the herd.

3) Evidence on the effect of pelagic sealing was obtained. The harem bull count had been under 1,400 in every year since 1906. In 1914, after 3 yr of closed seasons on pelagic sealing, it had risen to 1,559 (Osgood et al. 1915:39, 49).

4) Measurements of 2-yr-olds were first established from marked animals. Body length and other data were obtained from 16 males and 1 female (Osgood et al. 1915:66-67). (The largest "female" listed in the table on p. 67 was actually a male.) The program of measuring each summer the length of branded male seals was continued through 1918, at which time a table of length standards for seals in ages 1 to 6 yr was compiled (Bower 1919:96).

5) Osgood, Preble, and Parker realized that important zoological data—future rates of increase of the herd and survival rates of young seals to killable age—could be obtained from complete pup counts. The increase in the pup count from 1912 to 1913 was 12.4% and from 1913 to 1914 was 1.06% (Osgood et al. 1915:44, 74). These figures suggested a mean annual

Figure 5.—Top: Counting seal pups on Polovina Rookery, 8 August 1949; Lavrenty Stepetin foreground (photo by V. B. Scheffer). Bottom: Superintendent Edward C. Johnston warding off a harem bull during the annual bull count, Zapadni Rookery, 18 July 1948 (photo by K. W. Kenyon).

growth rate of 6.5% for a herd newly spared from pelagic sealing. They also indicated that great fluctuation should be expected as a normal feature of the annual birth rate. (This concept was overlooked in later years when the herd was, for a time, routinely managed without benefit of scientific studies.) The survival rates of young seals to killable age could only be learned, wrote the study team, if commercial sealing were to be resumed. It was not in fact resumed until 1918 (Parker 1917, 1918).

6) The team stressed the value of permanently branding a number of 3-yr-old males each year in order to insure a future breeding stock (Osgood et al. 1915:80). The idea was attractive but impractical. It was carried out only once, 9 yr later, when 5,047 males about 3 yr old were branded (Bower 1925a:118).

7) The team pointed out that body length of a seal, from nose to root of tail, on the killing field, is a better index of its age than is skin weight (Osgood et al. 1915:90). They designed the first calipers for use in the field. A breakdown of the Pribilof kill by age as determined from body length was first published for the season of 1917 (Hanna 1918:118) and last for the season of 1954 (Thompson 1956:64). The Bureau of Fisheries had abandoned, at the end of 1911, the practice of recording the salted-skin weight of every seal killed (Lembkey 1912:98). The weights of 11,733 skins taken that year ranged from 4 to 9.5 lb (1.8 to 4.3 kg).

8) At the conclusion of their report, the team noted that "no bibliography relating to the Pribilof fur seals has ever appeared" (Osgood et al. 1915:149). They met the need with a list of over 200 titles.

"Their carefully prepared report agreed in every respect with the findings of previous commissions, but [Secretary] Redfield paid no attention to its recommendations" (Jordan 1922, vol. 1, p. 611). He ignored principally the recommendation that killing of superfluous young males be resumed.

Parker continued an interest in the fur seal herd, especially in its growth (Parker 1915, 1917, 1918, 1928). He concluded (Parker 1915:3, 6) that "the natural relations are not far from one male to thirty or forty females." He interpreted the discrepancy in sexes as "imperfect" evolution, and adaptation of the fur seal as a "poor fit." As late as 1928 he still held the misconception that "the young cows are first impregnated at the end of their second year" (Parker 1928:1057). As a matter of fact, the females mature later than this. None are impregnated at the end of their second year, and few at the end of their third. The age of sexual maturity was not clearly understood until 1952, when, for the first time, large numbers of females were killed for scientific study.

A U.S. Navy radio station was established on St. Paul Island in 1914 and the Navy crew showed the first motion pictures on the Pribilofs on 21 June, in the carpenter shop (Parker 1946:153).

Preble continued to collect information on the wildlife of the Pribilofs, though he did not return to the islands after 1914. He and Waldo L. McAtee, a fellow naturalist of the Bureau of Biological Survey, published a general account of the wildlife there (Preble and McAtee 1923). McAtee never visited the islands. In the account, the only new information on fur seals was a note (Preble and McAtee 1923:142) that the sea lion louse ("*Echinophthirius fluctus*" Ferris, 1916) also occurs on the fur seal. This parasite was called *Proechinophthirius fluctus* by Ferris in 1951 (p. 300).

Routine Management for 25 Years, 1915-39

The management recommendations of Osgood, Preble, and Parker in 1914 were largely accepted by the Bureau of Fisheries. Under the careful leadership of Ward T. Bower, routine techniques for counting bulls and pups, for measuring rookery areas, for photographing the rookeries, and for estimating the age composition of the annual kill were gradually developed. These tasks fell to the island managers, administrative assistants, storekeepers, or schoolteachers. At the same time, many improvements in methods of harvesting seals and of processing their skins were made. Unfortunately, as we shall point out, no biologists or naturalists were on the scene, and scarcely any zoological research on fur seals was carried on during the 25-yr period. The main scientific and technological advances from 1915 to 1939 are given in the following pages.

In 1915 a U.S. industry was born. "The actual treatment of raw sealskins was begun at St. Louis in December, 1915 [by the Gibbins and Lohn Fur Skin Dressing and Dyeing Company]" (Bower and Aller 1917:107; Scheffer 1962:41). The first lot of processed skins was sold the following year by the Government's broker, Funsten Brothers and Company. In 1921, the Government transferred its contract from Funsten to Gibbins and Lohn, and in 1922, the principals of Gibbins and Lohn reorganized as the Fouke Fur Company, still in existence.

The old London terminology for finished sealskin grades was abandoned in 1918 in favor of the present one (Bower 1919:97). A "Middling Pup" skin, for example, became a "Medium."

In 1917, Arnold C. Reynolds and G. Dallas Hanna measured the space occupied by breeding seals on the Pribilofs (Hanna 1918:112). They proposed to establish a "square feet per breeding seal" ratio which could be used in the future as a census tool when the pups would become too numerous to count. Their estimate of the number of breeding seals was based on two fallacies: That the pregnancy rate is 100% and that the female is first bred at age 2. The sizes of the rookery areas in 1917 were: 1,354,546 ft^2 (125,841 m^2) on St. Paul Island; 172,305 ft^2 (16,008 m^2) on St. George Island; and a total on both of 1,526,851 ft^2 (141,849 m^2). The areas of St. Paul represented 89%, those on St. George 11%, of the total. In 1949, Kenyon et al. (1954:28) computed the rookery areas from aerial photographs at 3,566,519 ft^2 (331,340 m^2), or more than twice the 1915 value. The St. Paul-to-St. George ratio in 1949 was 81 to 19.

By 1917 the pups had become so numerous that they could be counted on only 11 of the 22 rookeries. Through strenuous effort they were counted in 1922 on all rookeries; this was the last complete count.

The age composition of a kill was first estimated in 1917 (Hanna 1918:118). The estimate was based on body length measurements of branded, known-age seals. The all-summer kill in 1917 included: 3-yr-olds, 57%; 4-yr-olds, 32%; and other ages, 11%. From an old photograph we learn that Hanna constructed in 1915 the wooden calipers which were first used in 1918 for measuring seals on the killing field and were last used in 1961. After 1961, the practice of measuring seals was abandoned and the method of estimating their ages on the basis of tooth-layer counts was accepted and used.

All of the Pribilof rookeries were photographed at the peak of the breeding season in mid-summer 1895 and in at least 5 other years: by Lembkey in 1905 (Lembkey 1905, 1905 (1911):178); by Hanna in 1917 (Bower and Aller 1918:97); and by Johnston in 1922 (Bower 1923:111), 1925 (Bower 1926:116), and 1948 (Thompson 1952a:45). The first series was reproduced in Townsend's 1896 report (Part 2-Atlas). Photoprints of the 1905 and 1948 series are filed in the Marine Mammal Biological Laboratory in Seattle. We do not know whether photographs taken in other years have survived. Originally, the intent was to photograph the rookeries at approximately 5-yr intervals from the camera stations established in the 1890's (Hanna 1918:97; Johnston 1923:111; Bower 1928:153). The photographs were a useful record of changes in the seal population from 1895 to about 1940, when the herd ceased to grow. Today, there is less reason to continue the program of photographing from prescribed camera stations, and more reason for exploring the possibility of aerial photography, followed by area mapping of the rookeries from vertical views.

Preble and McAtee (1923:117-118) gave numerous records of killer whales seen from 1875 to 1917. One killer whale seen off the Reef on 2 December 1902 "was playing havoc with a band of seals." At Northeast Point on 6 November 1904 "fragments of both cows and pups, the work of killer whales, were found strewn along the beach." Evidence of predation by killer whales upon seals has not, we believe, been reported since 1917. We conclude that killer whales have not changed their habits, but that Pribilof residents now spend less time watching the beaches than they used to.

Experiments in the use of seal by-products were conducted in 1917 during a wartime economy (Bower and Aller 1918:84-86). Bones, intestines, blubber oil, flipper gelatine, salted shoulders, and other products were examined. (A brief history of the use of by-products has been written by Baker 1950.) The first unit of a reduction plant was built on St. Paul Island in late 1918, to prepare meal and oil from seal carcasses (Bower 1919:83). It was operated in most years from 1919 to 1961 and converted into a freezer plant in 1964.

In 1917 dogs were prohibited on the Pribilofs (Bower 1919:107). This was presumably a reaffirmation of the ban of 1869 or 1870. Further to avoid disturbing the seals, sight-seeing trips to the rookeries and hauling grounds were first regulated in 1920. "Observation Rock," on Gorbatch, still marked by a painted arrow, was designated as a place where visitors might watch the seals (Bower 1921:73).

The Fur Seal Treaty of 1911 was slated to be reviewed in 1926. Partly to stimulate public discussion of a new treaty, five concerned naturalists of the American Association for the Advancement of Science formed, on 4 August 1921, a "Committee on Conservation of Marine Life of the Pacific" (Hanna 1922; Evermann 1922; Hanna footnote 9, p. 46; Nelson 1923). The Committee was later enlarged to 17. It recommended 1) that all maritime nations be parties to the treaty, 2) that pelagic sealing against both northern and southern fur seals be banned in all seas of the world, 3) that the clause permitting aborigines to kill seals be dropped, 4) that sealskin harvests on land not be shared by party nations, and 5) that all marine mammals and birds of the Pacific be protected by treaty. To date (1965) none of the recommendations has been acted upon.

When commercial killing was resumed in 1918, the Bureau of Fisheries took 34,890 skins, the greatest annual harvest in 29 yr. Faced with technological problems, the Bureau hired William P. Zschorna in 1919 to make a study of killing, curing, and processing skins. (Zschorna was later employed by the fur processing companies.) During the period 1919-22, three important changes were introduced (Bower 1920:77, 1921:75, 1922:54-55 and figs. 16, 17). First, skins were blubbered on the islands rather than at the St. Louis factory. Second, skins were washed and cooled in seawater rather than being placed, dirty from the field, into salt. Third, "stripping" replaced "knife skinning." Although "Old Jake Kochutin could skin a seal in less than two minutes" (Hanna footnote 9, p. 119), the new method of jerking the skin off the body was much faster, requiring only 10-15 s. We do not know when the special tongs now used in stripping were introduced. They have been improved several times; they are not patented. As late as 1943, a few skins were still being removed by knife (Bower 1944b:41).

As a result of the harvest of oversize males or "halfbulls" in 1918-20, many enormous skins were placed on sale. It is of historical interest to read that "the average price obtained for the entire take of bulls, including the minimum of 50¢ and the maximum of $169.00, was about $46.00 per skin" (G. Donald Gibbins, Fouke Fur Company, in letter of 13 October 1923 to G. Dallas Hanna).

During the closed season on commercial killing from 1912 to 1917, surplus male seals accumulated on the breeding grounds. Until their numbers were reduced, starting in 1918, they exerted a depressing effect on the size of the average harem. That is, "bull pressure" reduced the number of breeding cows that

a harem could effectively hold. The average harem fell to 26 or 27.

Year	*Average harem*
1912	60
1913	66
1914	60
1915	48
1916	33
1917	26
1918	27
1919	30
1920	41
1921	45

Thus the closed season, now seen by hindsight as a management error, provided us with biological evidence on the bull-to-cow relationship.

In 1921, two wooden towers with elevated approaches or "catwalks" were erected on the Reef to improve visibility for bull counting (Johnston 1922:78 and fig. 21). Many other towers have been erected on the rookeries since. Before 1921, the annual bull count had been made from high points on land, from ladders, from portable tripods, and from boats. The bull count first became an annual event in 1904.

In 1922 "at least 95 percent" of all pups on the Pribilofs were counted under the direction of Edward C. Johnston, storekeeper (Bower 1923:92). A full count has not been made since. Johnston started his career in 1911 as a clerk on the *Albatross*, spent the years 1919 to 1927 in teaching and administrative work on the Pribilofs, returned in 1939 as superintendent, and retired in 1949 as general manager (Bower 1920: 74; Thompson 1952b:57).

Also in 1922, the sizes of the rookery areas were estimated and were reported to be no larger than in 1916. The rookeries were photographed from fixed camera stations, as they had been in 1917 (Bower 1923:93).

Hanna (1921a) described the organs of two hermaphroditic seals obtained on the killing fields in 1918. No one has reported since on this abnormality in fur seals, though Scheffer (1951) has described cryptorchidism.

Hanna also measured heart temperature in 71 seals. He concluded that "the normal temperatures of bachelor seals as received on the killing fields in a thoroughly cooled condition are about 101 °F" (Hanna 1924:53). This value is too high; it probably represents the temperature of excited seals. Hanna also found that one seal, which died in convulsions during a drive, had a temperature of 108.9°F (42.7°C). "Upon examination it was found that the fur [of this seal] had loosened and could be easily plucked with the fingers." For many years, the skin from a seal which died from exhaustion and overheating in a drive was known as a "roadskin" and was marked for special attention by a loop of rope through the armhole. No special handling is given to such skins today.

In mid-July 1922, Leonhard Stejneger stopped briefly at St. Paul Island en route to an inspection of the Commander Islands rookeries (Stejneger 1923, 1925). At Bering and Copper Islands, he saw the old flag of Imperial Russia still flying, 6 yr after the Revolution. He visited certain rookeries where he had stood just 40 yr before, in July 1882. The seal industry of the Commanders was in deplorable condition and the seal population had fallen to about 18,000, mainly as a result of pelagic sealing. A Bureau of Foreign and Domestic Commerce report for the following year, 1923, gave the Commander population as only 12,562 (Bower 1926:160).

In 1923, the Bureau of Fisheries decided to insure an escapement of males for the breeding reserve by marking and sparing a prescribed number during the harvest. That year, 10,017 seals were marked by shearing or hot-iron branding, or both (Bower 1925a:119). The task must have been difficult. In later years, branding was resorted to intermittently and on a small scale only. After 1926, shearing operations were postponed until the close of the killing season; after 1932, marking for the breeding reserve was abandoned (Bower 1933:64; Scheffer 1950d:6-7). "Of the animals marked by shearing [in the second year of reserving operations, 1924], 1,000 were further marked by clipping off the tips of both ears" (Bower 1925b:149). The results of this experiment are not recorded.

In 1922, Henry W. Elliott persuaded Senator Hiram W. Johnson to introduce a bill (S. 3731, 67th Congress) which would change the method of harvesting and selling sealskins (U.S. Congress, Senate 1923). For each skin, its "salted length and girth [width]" (U.S. Congress, Senate 1923:1) would be measured; no seal could be killed, the skin of which when salted was < 37.5 in (95 cm) long; all skins would be sold in raw salted condition. At a Senate committee meeting on the bill on 2 February 1923, Elliott again met in debate his old adversary, David Starr Jordan. The bill was not endorsed by the committee (U.S. Congress, Senate 1926:2).

In 1926, Elliott lobbied successfully for the introduction of a bill similar to the one proposed in 1922. It went further. It would oblige the Bureau of Fisheries to mark permanently all 3-yr-old males spared annually for the breeding reserve (U.S. Congress, Senate 1926). Elliott, at the age of 80, appeared before the Senate committee to speak for the bill and to reiterate charges that the Bureau was deliberately and illegally killing yearling seals. His effort brought no new legislation, though perhaps his self-appointed role as watchdog of the seal herd may have been useful in exposing management to public criticism.

Johnston (1925:136) observed that "cows that were branded in 1902, or before, with a single bar across the back continue to appear on the rookeries of St. George Island. Three were seen in 1923. These are at least 21 years old. . . ." No older seals were recorded until the 1960's, when improved methods of reading the age of a seal from its teeth were developed.

The first report of twin fetuses in a fur seal was obtained in 1923 on the 10th of May, when a Bureau of Fisheries agent examined an adult female killed by Tlingits off Biorka Island in Sitka Sound (Johnston 1925:136).

In 1923 "Mr. Keishi Ishino, fur-farming expert of the Imperial Fisheries Bureau [of Japan]" spent a month on the Pribilofs "making a careful study of questions pertaining to fur seals" (Bower 1925a:111). He returned in 1926 (Bower 1927:303). His second visit was doubtless concerned, in part, with international relations. The Fur Seal Treaty of 1911 was to continue in force until 15 December 1926 and thereafter until terminated by 12 mo written notice given by one or more of the parties.

"In January, 1926, Japan proposed to the other three signatory Powers that a conference be called to revise the 1911 Convention, to make the regulations less stringent in order to decrease the number of seals . . . coming into Japanese seas and seriously damaging the Japanese fishing industry; but as

the United States had not then . . . recognized the Soviet Government in Russia, it declined to join in any conference or to discuss any new agreement with Soviet Union representatives" (Ireland 1942:406).

Many years after Ishino's second visit in 1926 we found out the main reason for it. About 1925, Japanese fishery agents first learned that Pribilof-marked seals were showing up on the Commander Islands, on Robben Island, and in waters off Japan (Japanese Bureau of Fisheries 1933). Ishino wrote that "when I went to the Commandovsky (sic) group in 1925 . . . I happened to find there several animals bearing tags [they could only have been brands or sheared areas] of the Pribilof Islands. I found some of these marks also at Seal [Robben] Island . . . [My idea on intermingling] was then communicated to the American authorities who, however, refused to accept my theory" [Isino (sic) 1939:43-44]. Twenty-five years elapsed from the first notice of intermingling in 1925 until Austin and Wilke (1950:34) made the first attempt to estimate the magnitude of it.

When, therefore, Ishino arrived on the Pribilofs in 1926 he arranged that "for the purpose of investigating the route of . . . migration, special marks should be put on males of three years of age each year for three years after 1926 at both the American and Japanese breeding grounds" (Japanese Bureau of Fisheries 1933:11-12). Accordingly, in July 1927, Pribilof Superintendent Harry J. Christoffers placed small aluminum fish tags on the flippers of 200 bachelor seals estimated to be 3-yr-olds. He repeated the tagging in 1928 and 1929 (Scheffer 1950d:8). The experiments were not publicized, though they were recorded in the St. Paul Island log. Subsequently, 28 tags were recovered on the Pribilofs, 28 in waters off Japan, and 1 on the Commander Islands.

We believe that all of the rookeries were photographed from land stations in 1925, though not mentioned in the published annual report for that year. (See under photographs for 1948.)

Ten fur seal heads were collected from the killing fields in 1926, packed in dry salt, and shipped to A. Gerson Carmel, Department of Anatomy, University of Cincinnati. Carmel published in 1928 (p. 347) a beautiful roentgenogram of one of the heads.

In the summer of 1928, Harry W. May of the Fouke Fur Company first visited the Pribilofs. Except for the war year 1942, he returned each summer through 1962 and again in 1965, setting a record of 35 summers on the islands. During most of the later years he was in charge of island operations (curing and barreling) for the Company. He retired in September 1965.

The first Soviet visitors to the islands spend 11 d there in June 1929, "observing fur seals and making general observations of the activities" (Bower 1930:333). They were Leonty Vasilievich Boitsoff and Titus Ardeevich Malkovich.

In 1930, the practice of killing seals in autumn was discontinued (Bower 1931:80). During most years from the beginning of U.S. ownership a small fraction of the annual harvest had been taken in autumn, mainly to provide the Aleuts with food. The so-called "food killings" had dwindled to 800 seals in 1929.

A fur seal breeding in captivity was first recorded in the National Zoological Park in Washington, D.C., in 1932. Two males and four females, all about 2 yr old, had been delivered to the Park in 1928. On 31 July 1932, the only survivor gave birth to a stillborn pup (Bower 1929:323, 1933:72).

Japan had opened negotiations in 1926 to revise the Fur Seal Treaty and she did so again in 1936, to no avail. The Japanese "built their whole case on the unproved assumption that the wintering seal population off Japan is composed of most of the Commander and Robben Island seals, plus one-half the Pribilof herds" (Austin and Wilke 1950:25). The claimed annual damage to the Japanese commercial fishery as a result of predation by seals was about $7 million.

R. A. Partridge, a student from the University of Cincinnati, visited the Pribilofs about 1936 and systematically collected samples of skin from six bachelor seals. He later published an analysis of lipid materials (Partridge 1938).

Nothing had been known of the food habits of fur seals during migration south of the Gulf of Alaska. In the 1930's, four studies were carried on by fishery agencies of the United States and Canada, designed to evaluate the importance of predation by seals upon salmon and other commercial fishes (Clemens and Wilby 1933; Clemens et al. 1936; Schultz and Rafn 1936; May 1937). The results were summarized by Scheffer (1950f:8-9). Altogether, 256 seal stomachs containing food were purchased from Indians at Sitka, Alaska; at points along the west coast of Vancouver Island, British Columbia; and at La Push, Wash. The principal food remains, listed in order of frequency were: Pacific herring, *Clupea harengus pallasi*; squid; smelt; salmon; greenling; and pilchard. Pacific herring appeared in stomachs more often than all other food species combined. After the 1930's, no food habit studies were made until Kenyon visited Sitka in March 1950.

The first aerial survey of the rookeries was made in 1938, when Pribilof Superintendent Harry J. Christoffers "made a trip from the [St. Paul] village landing to Northeast Point and return" in a small seaplane from the U.S. Coast Guard cutter *Chelan* (Christoffers 1940:162). Motion pictures and still pictures taken by the Coast Guard did not show the seals distinctly.

On 1 July 1939, the Bureau of Fisheries, Department of Commerce, and the Bureau of Biological Survey, Department of Agriculture, were transferred to the Department of the Interior. A year later, on 30 June 1940, the two Bureaus were merged to form the Fish and Wildlife Service (Sater 1960:9).

THE MODERN PERIOD, 1940-64

Establishment of Continuous Research, 1940-51

Preface

Some information on research during the modern period is available in scientific journals or special Government reports; some is scattered through the published annual reports of the fur seal industry through 1956; much of it is contained in unpublished administrative reports. Annual progress reports of the Marine Mammal Biological Laboratory have now started to appear in print. In the following section, where the source of a statement is not shown, it is manuscript material in the research files of the Laboratory. While the headings by year are shown, scientific studies are not necessarily described in chronological order. The origin of a project or idea is dated by the initial year; it may be followed by a description of later, long-time developments.

1940

The year 1940 is important in fur seal history for three reasons: 1) By 1940 or thereabouts, the Pribilof seal herd had reached a population plateau. Limited by its natural environment and by commercial cropping, the herd was no longer able to grow. The fact was not recognized in 1940 (Kenyon et al. 1954, fig. 13 on p. 42). 2) On 23 October 1940, the Japanese Government gave formal notice of abrogation of the Treaty of 1911, on the ground that the increased number of fur seals in the North Pacific was causing serious damage to her fishing industry (Bower 1942:54; Tomasevich 1943:66; Roberts 1945: 270). This break eventually led to a better treaty in 1957 containing provision for a sustained research program. 3) On 30 June 1940, the U.S. Fish and Wildlife Service was created. As a result, mammalogists and fur seal managers, brought together for the first time in the same Service, were able to take a fresh look at fur seal biology and the fur seal population. Since then (except for the war year 1942), the seal herd has been under continual study by one or more biologists.

By 1939, two reliable statistics of the herd—the number of harem bulls counted and the number of seals killed in June and July—were falling progressively each year below expectations. This led to suspicion that the method of annually computing herd size was faulty. So firmly established, however, was the method that it remained in use until 1947 by which time it was producing figures far removed from reality and its use was abandoned (Thompson 1952a:51).

In early 1940, Ira N. Gabrielson, then chief of the Bureau of Biological Survey, learned that he would soon be responsible for the fur seal herd. He asked Frank Getz Ashbrook, in charge of fur-animal investigations for the Biological Survey, to draft a plan of research on seals. As part of that plan, collaborator Robert K. Enders, of Swarthmore University, listed (in memo of 2 May 1940) many important, unanswered questions with regard to fur seal reproduction. Among them were: When do the males and females mature sexually? What is the average length of their breeding life? Is implantation delayed? What is the optimum sex ratio of breeding adults?

Enders did not have an opportunity to visit the seal islands, though he and two of his graduate students maintained an interest in fur seal reproduction and published three papers on the subject (Enders 1945; Enders et al. 1946; Pearson and Enders 1951).

Gabrielson and Ashbrook visited the Pribilof Islands in the summer of 1940 and became acquainted with the research problems involved in seal management. Also present was Harry C. Fassett, who had collected plants at Unalaska in 1890. He was an amateur naturalist, and formerly captain's clerk of the research vessel *Albatross*. He was appointed agent of St. Paul Island in 1914 and remained on the Pribilofs for some years thereafter, Also present in 1940 was Victor Blanchard Scheffer, a biologist of the Biological Survey who was sent to the Pribilofs in June for 4 mo to study the seal population (Scheffer 1940[10]). He had spent the summers of 1937 and 1938 in the Aleutian Islands (Murie 1959). Part of his job on the Pribilofs was to criticize the methods of estimating age and sex composition of the herd, and where methods were found inadequate or obsolete, to recommend new ones. Of historical interest are the following points in his report:

1) With the help of Aleuts who remembered how counting had been done in 1924, all pups on Zapadni Reef were rounded up, made to "run the gantlet," and were counted on 13 August. The total was 3,250 ± 100 living pups and 196 dead. These figures did not agree with the official ones arrived at by pure computation—1,200 living and 10 dead (Johnston 1942: 71). The discrepancy highlighted the need of research.

2) During September, 5,000 pups were hot-iron branded in order to provide specimens of known age for future anatomical studies and to establish a basis for Peterson-type (1896) population studies. Pups had last been branded for scientific purposes in 1912. Branding in 1940 (Fig. 6 top) was a slow and disagreeable job, and was probably harmful to the pups.

3) Noting that only two females from the 1912 brandings had later been killed for study, Scheffer (footnote 10) (Fig. 6 bottom) recommended that known age females from the 1940 brandings be killed systematically to provide information on reproductive anatomy. He was handicapped in 1940, however,

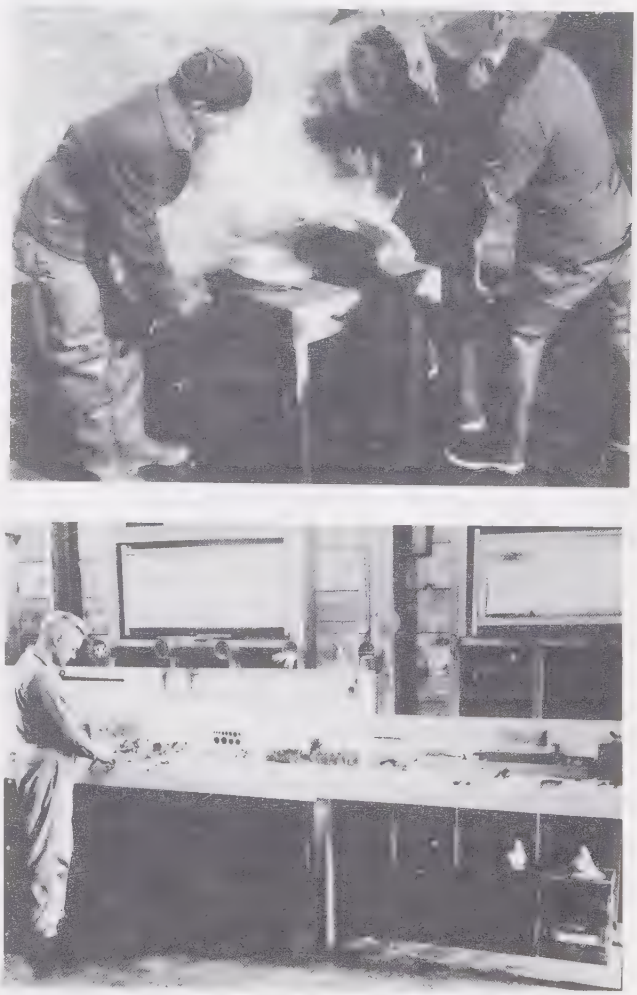

Figure 6.—Top: Branding seal pups on the Reef, 27 September 1940 (photo by V. B. Scheffer). Bottom: Victor B. Scheffer in his St. Paul laboratory 8 July 1945, self-portrait (photo by V. B. Scheffer).

[10]Scheffer, V. B. 1940. Report on studies in the Pribilof Islands, Alaska, in the summer of 1940. Section on fur seals followed by correspondence and comments. Unpubl. rep., 224 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

by the terms of the Treaty of 1911, which made no provisions for taking specimens.

4) Bewildered by the numbers of seals on the breeding grounds and their constant movement, he recommended that "an intimate life history study of a single harem throughout a summer" be made (Scheffer footnote 10, p. 223).

5) He wrote that "determined efforts . . . should be made to perfect a technique of airplane reconnaissance of the seal grounds" (Scheffer footnote 10, p. 215).

6) He was disturbed by a discrepancy between the observed rate of increase in number of bachelors killed and the computed rate of increase in number of breeding cows, the latter rate being about three times the former (Scheffer footnote 10, p. 219). He questioned the computation system and especially the publication of its results in minute detail. As a visiting British scientist wrote later: "The annually published computation, despite small textual disclaimers, has suggested to the world a knowledge of the composition of the herd which goes far beyond what is proven" (Bertram 1950:81).

1941

With the Fur Seal Treaty due to expire in October, the U.S. Government made plans early in 1941 to investigate the food habits and migration routes of fur seals at sea. The main purpose was to find out how many Pribilof-born seals were wintering in waters off Japan, and what they were eating there. The Secretary of the Interior wrote to the President on 7 March 1941 recommending that funds be made available to support a sea-going vessel, a staff of five biologists, and clerical help. The sum of $290,000 was appropriated on 30 June.

On 7 March the Secretary of the Interior proposed to increase the 1941 take of fur seals by about 30,000 as a step in the direction of reducing the Pribilof herd. The kill was, in fact, increased by 29,750 over that of the previous year (Bower 1943:47).

When funds were appropriated, the following biological staff was assembled: Victor B. Scheffer (in charge), A. Henry Banner, Kelshaw Bonham, Wilbert M. Chapman, Donald D. Shipley, and Ford Wilke. A 3-masted motor vessel, the *Black Douglas*, was purchased and refitted for pelagic research. When the United States entered World War II on 7 December 1941, the vessel was given to the U.S. Navy and all plans for pelagic research were shelved.

Meanwhile, during the summer and fall of 1941, Wilke and Banner were carrying on research on the Pribilofs. Their main accomplishments were: 1) Between 18 August and 16 September they counted 19,000 dead pups on all of the St. Paul rookeries, representing a mortality of at least 4.2% (Kenyon et al. 1954, table 11, p. 30). Here was the first evidence that pup mortality was beginning to increase as a result of population pressures. 2) Between 23 September and 8 October they branded and tagged 10,000 pups, experimenting with different tags and different tag positions on the body (Scheffer 1950d:4, 9). From this experiment, the present monel metal tag applied to the fore flipper evolved. (In 1941, 5,000 of the tags applied were of stainless steel; this metal was not used again.) The main purpose of the 1941 marking was to identify animals of Pribilof origin, some of which could later be collected by the *Black Douglas* biologists studying intermingling of seals off Japan. Tags of the 1941 series were recovered over a period of 20 yr; four tagged females were observed in 1961.

Sex was recorded at time of tagging for the 10,000 pups, and also for 1,000 pups tagged in 1945. Sex was not recorded in tagging operations after 1945. How accurate were the sex determinations of 1941 and 1945? Of 511 seals recovered in later years: 82% proved to be males correctly identified, 10% proved to be females correctly identified, 1 seal proved to be a male incorrectly identified, and 8% proved to be females incorrectly identified. Thus, the only important mistake was in identifying many male pups as females. 3) Between 7 October and 7 November, they collected and measured 18 branded yearlings. Their collection of skins and skulls is still the largest for known-age yearlings. They started the "BDM" (*Black Douglas* Mammal) catalog in which specimens are still being listed. 4) They stood a 24-h watch on one of the rookeries and learned that seals are active and vocal at night as well as day. 5) They studied U.S. Weather Bureau records, and could find no correlation between Bering Sea weather and the time of arrival of bachelor seals in June and July. 6) They made the first collection of genital tracts from known-age females: 6 tracts from branded yearlings which were subsequently sent, we believe, to Robert K. Enders. 7) In late November and early December they experimented with snaring and crating live fur seals. Ten crated seals left St. Paul Island by boat on 11 December, but only seven arrived, somewhat the worse for wear, in Seattle on 3 January 1942. They were placed in the Seattle Zoo on the same day (Anonymous 1942). One survived for as long as 110 d. This one "fed heavily for a 47-day period during which its average daily consumption of fish was 5.73 pounds or 14 percent of its weighted average body weight" (Bonham 1943). Here was the first attempt to estimate the food consumption of the fur seal.

Leon J. Cole collected seal pituitaries on St. Paul Island in the summer of 1941 and sent them to Roland K. Meyer (both men from the University of Washington). Scheffer collected 13 pituitaries in 1946 and sent them to Robert K. Enders. We do not know the fate of any of these specimens.

The Fur Seal Treaty expired on 23 October 1941. By an exchange of notes between the United States and the Dominion of Canada, a provisional arrangement was made on 19 December 1942, in which the United States was to receive 80% and Canada 20% of the annual sealskin take. A domestic Fur Seal Act embodying all important features of previous protective legislation was signed by the President on 26 February 1944 (Public Law 237, 78th Congress, Chapter 65, 2nd Session). The provisional agreement remained in effect until 1957. An important feature of the 1944 Fur Seal Act was that it provided for the killing of fur seals "for scientific purposes under special permit issued therefor by the Secretary (of the Interior)" (Section 16). It also required each party to report at the end of each calendar year the number of seals taken for research use, and the data obtained from them. Such a report, usually consisting of from one to three pages, was submitted annually by the United States (and we presume by Canada also) through 1956.

1942

In the spring of 1942, the Aleutian Islands became an active war theater. By military order, the residents of the Pribilof Islands were moved on 16 June and were relocated in Funter Bay, southeastern Alaska. (Roy D. Hurd was, for a week, the

only human on the islands.) The people were returned in early summer 1944 (Bower 1944a:42, 1946:55).

Fur seal research came to a halt. Wilbert M. Chapman continued for several months to study the bony skeleton of fishes. He reported (Chapman 1943:157-158) that the mysterious "seal fish" of Lucas (1899c), hitherto known only from fur seal stomach contents, was actually the deepsea form *Bathylagus* sp. Strangely, the "seal fish" was not identified in seal stomachs in the 20th century until the summer of 1963. Chapman (1942:194) also made an estimate of the amount of fish and squid consumed annually by the Pribilof seal herd: 2.5 billion pounds (1.1 billion kg). A closer estimate today would be 1.5 billion pounds (0.7 billion kg).

1943

Sealing was resumed in 1943 under a wartime blackout. The take of 117,164 skins was the largest since the uncontrolled slaughter of the year 1868. It represents about as many 3- and 4-yr-old males as can be taken on land in a season.

From 15 May to 4 October 1943, Lawrence J. Palmer, a Fish and Wildlife Service biologist with long experience in studies of reindeer, was stationed on St. Paul Island (Palmer 1943[11]). His main assignment was to record the number of branded male 2- and 3-yr-old seals appearing in drives, and from the resulting data, to estimate the total size of each age group. He recorded the following numbers of branded animals (Palmer footnote 11, p. 31-32):

Males	*Clubbed*	*Released*	*Total*	*Total adjusted for seals released and recurring in drives*
2-yr	138	134	272	—
3-yr	448	285	733	589

Unfortunately, he had no good way of calculating the proportion of branded to unbranded animals within the 3-yr-old age group, i.e., he had no good way of estimating the total number of 3-yr-olds killed. The age composition of the kill was (as we now know) very imperfectly indicated by the data obtained in 1943 from measuring the "field length" of seals killed. At any rate, Palmer (footnote 11, p. 34) approached the truth in concluding that the computed herd size was one-half million too large.

Palmer obtained the first quantitative information on the percentage of marked animals returning to the place of their birth. Of 111 tagged 2-yr-old males recovered in 1943, 28% were on a hauling ground adjacent to the home rookery (Palmer footnote 11, p. 40).

1944

Scheffer returned to the Pribilofs in the summer of 1944 and in many subsequent summers. The main research accomplishments in 1944 were as follows: 1) A collection of known-age (marked) specimens was begun. From 43 males and one 4-yr-old female, the measurements, skulls, and skins were saved. The systematic collecting of reference material was carried on in later years until seals through age 10 had been represented. The specimens and measurements proved to be of value later in describing special features such as the pelage and dentition. 2) Further evidence was obtained that the "field length" of a seal, while it may have been a useful index of age in 1915-16, when the age-length relationship was calculated, was no longer valid. Of known 3-yr-olds measured in 1944, 82% fell within the standard range; of known 4-yr-olds, only 50%. Later, Scheffer concluded that the average fur seal had diminished in size over a 30-yr period as a result of population crowding (Scheffer 1955). 3) Hookworms, *Uncinaria lucasi*, in seal pups were recorded for the first time since 1912. Ten carcasses selected at random from 127 found on the white sands below Hutchinson Hill proved to be infested. The question loomed: "Is this another symptom of a herd which has ceased to grow?" 4) A peculiar nasal mite, *Orthohalarachne attenuata* (Banks), had been described in 1910 from specimens found on a fur seal pup. When Scheffer returned to St. Paul Island in the summer of 1944, he noted that nasal mites were common in seals of all ages. He collected specimens and forwarded them to G. F. Ferris and Irwin M. Newell. In the meanwhile, Doetschman (1944) had described a new species, (Halarachne) *O. diminuata*, from the California sea lion, *Zalophus californianus*. Shortly thereafter, Newell (1947:256, 260) reported that *O. diminuata* was present, along with *O. attenuata*, in the collections made on St. Paul in 1944 and 1945. Kenneth A. Neiland, of the Alaska Department of Fish and Game, reported (in letter of 25 January 1962) that he had found a young fur seal suffocated by a heavy infestation of nasal mites. 5) In the summers of 1944, 1945, and 1946, acanthocephalans (thorny-headed worms) were collected from the intestines of killing-ground seals. Some were sent to James E. Lynch, who forwarded them to Harley J. Van Cleave, and some were sent directly to Van Cleave. As a result, acanthocephalans were recorded for the first time from the fur seal. Three species were identified: *Corynosoma semerme* (Forssell) 1904, *C. strumosum* (Rudolphi) 1802, and *C. villosum* Van Cleave 1953. For details, see Van Cleave (1953a, b). 6) The testes of about 130 seals were collected, measured, and preserved as evidence of the age when spermatogenesis first begins. The collection was later lost, though measurements of these and other specimens subsequently showed that the testes grow most rapidly in weight in the third or fourth years, especially the fourth year (Scheffer 1950e:389). 7) An inquiry addressed to the Pacific Scientific Research Institute of Marine Fisheries and Oceanography (TINRO), Vladivostok, U.S.S.R., in 1944 was answered from Moscow the following spring. Seals with U.S. tags had, indeed, been recovered on the Commander Islands (Taylor et al. 1955:63). While seals thought to have been branded or sheared on the Pribilofs had been recovered from time to time on Asian breeding grounds, here was clear proof of intermingling. 8) In 1944 a bachelor seal wearing a peculiar, soft, black-rubber collar was captured on St. Paul Island (Scheffer 1950d:20). Up to the end of 1948, 10 seals with similar collars were recovered, and as late as 1965 Peterson (1965b:18) wrote that "fur seals continue to appear on the Pribilofs every year wearing black rubber collars of unknown origin." The most plausible explanation is that the collar is the rolled-sheet-remnant of a rubber food bag manufactured in Japan. 9) Bulls were counted on selected rookeries on St. Paul Island at 10-d intervals in May,

[11]Palmer, L. J. 1943. Investigations of branded fur seals, Pribilof Islands, Alaska, 1943. Unpubl. manuscr., 45 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

June, and July 1944. The results suggested that maximum numbers of harem bulls are on station by the end of June. 10) A "cryptorchid" seal was collected for study. In later years four others, ranging in age from 10 to 15 yr and in weight from 190 to 329 lb (86 to 149 kg), were examined (Scheffer 1951). The name "cryptorchid" was not entirely appropriate. True, the testes in such individuals fail to descend (cryptorchidism) but they also fail to develop normally. Such individuals are locally known as "big cows."

1945

Up to 1945, no naturalist had described an early fetus of the fur seal. On 16 January 1945 a fisherman found a seal tangled in his net off the Oregon coast. It was delivered to the Marine Mammal Biological Laboratory in Seattle and found to contain a fetus of 372 g (Scheffer 1946) (Fig. 7 top).

Scheffer and the first of a long series of "summer biologists," Norman O. Levardsen, spent the summer of 1945 on the Pribilofs, mainly in collecting, measuring, and photographing material from known-age seals. On 24 and 25 August they placed large tags, larger than either of those used in 1941, on 973 pups on Tolstoi Rookery. The tags were later found to be successful, though at the time of application, they seemed too large (Scheffer 1950d, fig. 5, p. 12).

Figure 7.—Top: The first small fetus of a fur seal to be studied by the Pribilof biologists; a female weighing 0.8 lb taken from a seal drowned in a shark net off Depoe Bay, Oreg., 16 February 1945 (photo by V. B. Scheffer). Bottom: Gary A. Baines counting dead seal pups on Polovina, 3 September 1957. He is marking each with a dash of white plaster (photo by F. Wilke).

Hookworms obtained from a seal pup in July 1945 enabled Baylis (1947) to redescribe *Uncinaria lucasi* Stiles 1901. "*Uncinaria* sp." had been sketched by Stiles and Hassal (1899:165) on the basis of five worms collected by Lucas in 1896. The authors stated that additional specimens were collected by Lucas in 1897, too late to be described in the (Jordan Commission) monograph. Later Stiles (1901) mentioned that he had named the worm "*Uncinaria lucasi*" but gave no further description of it.

Seals with reddish patches on the guard hair are frequently seen on the killing fields. In 1945 it was learned that the color is caused by red algae. To date the following species of algae commensal on fur seal hair have been identified: (Marine Mammal Biological Laboratory, file 6.05/05) diatoms (*Grammatophora* sp. and *Licmophora* sp.), brown algae (*Ectocarpus* (*siliculosis*?) and *E.* sp.), and red algae (*Erythrocladia subintegra* and *E.* (*polystromatica*?)).

The first planned attempt to use aerial photography as an aid in counting seals was made on the afternoon of 9 July 1945. At the request of the Fish and Wildlife Service, the U.S. Navy sent an amphibious plane (PBY) from Adak. The aircraft flew at elevations between 300 and 500 ft (90 and 150 m). A photographer shooting through a hatch in the floor of the tail took at least 83 photographs of St. Paul Island rookeries. Photoprints, but not negatives, are on file in the Marine Mammal Biological Laboratory. They are unsharp and are not suitable for area mapping, since many of them represent oblique shots.

In July, Anne K. Wogan, food technician from Philadelphia, set up a small cannery and smokehouse on St. Paul Island and experimentally preserved liver paste, sausage, groundmeat patties, and other products from fur seal carcasses. "The concensus was that products of a similar nature, already on the market, were as good or better, and probably far less costly to produce in quantity" (Ralph C. Baker, in letter of 30 August 1965).

1946

In 1946, Georges Prefontaine (University of Montreal) and G. Clifford Carl (British Columbia Provincial Museum)[12] represented the Canadian Government as observers. They were the first Canadian biologists on the islands since Macoun and Harmon in 1914.

A newborn, 9-lb (4 kg) seal pup was placed in a tank of seawater. It swam vigorously for 20 min, disproving a longheld contention that the pup must be taught to swim.

Tapeworms, common in the fur seal, had never been identified. Specimens were collected in 1945 and were sent to Horace W. Stunkard; others were collected in 1946 and were sent to Robert A. Wardle. No satisfactory name for genus or species resulted (Wardle et al. 1947; Stunkard 1947, 1948). Stunkard

[12]Prefontaine, G., and G. C. Carl. 1946. Report on a visit to the fur sealing grounds, Pribilof Islands, Alaska, in 1946. Unpubl. rep., 30 p. with various maps and blank record forms, also 36 photographs. Fish. Res. Board Can., Pac. Biol. Stn., Nanaimo, B.C. V9K 5K6 Can.

decided that the worms from the fur seal "represent 2 species, one monogonadic, the other diplogonadic" (Stunkard 1947: 19). It is unlikely that a satisfactory name for the tapeworm of the fur seal will be agreed upon in the near future (Vik 1964).

Fur seals had long been known to have "worms." Stiles and Hassal (1899:109) were first to identify the stomach roundworm as "*Ascaris decipiens* Krabbe, 1878." After examining a collection of worms sent to him in 1946, Baylis reaffirmed (in letter of 25 November 1946) that "*Porrocaecum decipiens* (Krabbe) 1878" is the common stomach worm. Myers (1959) proposed the generic name *Phocanema* for the ascarids of marine mammals, and Neiland (1961) found "*Phocanema decipiens* (Krabbe, 1878) Myers, 1959" in the stomach of a pelagic yearling fur seal at Valdez.

At time of writing (1965) we believe that *Phocanema decipiens* is the only ascarid worm recorded from *Callorhinus* in the eastern North Pacific. Others would be expected, particularly *Phocascaris osculata* (Rudolphi) 1802, which was reported by Baylis (1937:124) and Berland (1963:20) in many northern and southern pinnipeds, including the South American fur seal, *Arctocephalus australis*.

In 1946, the skins of 523 male seals were marked on St. Paul Island according to "field length" in inches, and the skins were followed through the factory in St. Louis to the final auction. In each of 11 classes there were approximately 50 skins. The classes and the mean sale returns were as follows:

Field length (inches)	*Dollars*
41	56
42	59
43	60
44	68
45	69
46	75
47	78
48	79
49	81
50	80
51	79

The mean return of Group III skins (from 41- to 45-in (104-114 cm) seals) was $62.27 and from Group IV skins (from 46- to 51-in (117-129 cm) seals) was $77.97. The results were used as an argument in favor of killing a greater percentage of large seals each summer.

Samples of fur seal liver were frozen and shipped to Seattle in 1946, 1947, and 1948 for analysis of vitamin A content. At that time, vitamin A had not been synthesized and natural sources were in great demand. Over 400 lb (180 kg) of liver were analyzed (Miyauchi and Sanford 1947; Sanford et al. 1949; Scheffer et al. 1950). The light, yellowish-brown livers contained more oil and distinctly more vitamin A than did the dark, reddish-brown ones. The content ranged on the order of 1 to 1,000. The biological reason for the variation has never been explained. One liver contained $4.25 worth of vitamin A at going prices.

Clegg (1951) analyzed oil from cold-rendered seal blubber collected in 1949. It was fairly unsaturated (iodine number 108) and had 1.58% free fatty acid. Wilber (1952) analyzed a sample of orange blubber. He was unable to identify the carotenoid (?) responsible for the color. He found 0.24% cholesterol and 4.3% phospholipid.

A report by Enders et al. (1946) on the reproductive anatomy of the female seal was the first to be published since the 1890's. The authors examined preserved tracts collected on the Pribilofs between 1940 and 1945. They discovered and described the blastula. They reported that the post-parturient uterine horn shrinks rapidly, within a week or so. They first postulated delayed implantation; they estimated 2 mo, though the delay is in fact about 4 mo.

Fredericka Martin's book "*The hunting of the silver fleece*" appeared in 1946. It pointed out inequalities between the treatment of "natives" (Aleut-speaking) and "whites" on the Pribilofs. As one result, a Government committee was sent to St. Paul Island from 2 to 9 October 1949 to investigate living conditions (Martin 1946b; U.S. Interior Department 1951).

1947

In 1947, after the war, plans to reactivate the *Black Douglas* and to undertake pelagic fur seal research were laid. Congress appropriated $62,500. Biologists William H. Sholes, Jr., Karl Walton Kenyon, and Robert Zanes Brown entered on duty in May and June. Raul Vaz-Ferreira, of Servicio Oceanografico y de Pesca, Uruguay, was on the Pribilofs and on the *Black Douglas* as an observer during summer and fall. He had studied South American fur seals on the islands off the Uruguayan coast.

In 1947, the *Black Douglas* cruised 17,256 mi (27,771 km) in two trips out of Seattle. The first one took her to the Pribilofs and return, with side trips, from May to August. The second one took her to Attu Island, westernmost of the Aleutians, from September to November. As a seal-hunting base the ship was much too large. Biologists aboard her in 1947 shot and recovered no seals. On the first cruise, on 6 June, they discovered about 100 fur seals hauled out on Samalga Island, in the eastern Aleutians. This was the first evidence that Alaskan fur seals land outside the Pribilofs. On the second cruise in late October and November, along the full length of the Aleutian chain, the biologists saw only 10 seals.

Marking operations were resumed in 1947 with the tagging of 19,183 pups. For the first time, a "checkmark" was placed on each pup when tagged: a small hole punched in the web of a hind flipper. A checkmark of one kind or another is now routine. Pups have been tagged annually since 1947 (Fig. 8), when the "A" series tags were applied (except in 1950). We will give only highlights of later tagging programs.

Efforts were continued to photograph the rookeries for census purposes. A camera was sent aloft on small captive balloons (Fig. 9) in 1947-49 but the resulting pictures were unsharp. An infrared photograph taken from a ground station in 1947 was distinct, though little more so than an ordinary photograph.

An observation blind was built beneath one of the catwalks on Polovina with the thought that a photographer could obtain intimate, eye-level shots of seals. However, the approach was via trapdoor in the catwalk and the seals took alarm at seeing a man above them.

An "average harem" statistic was last published for the year 1947 (Johnston 1950:74). "The computed average harem con-

Figure 8.—Top: Tagging seal pups with "A" series monel tags on Polovina Rookery, 24 September 1947, William H. Sholes, Jr., at right (photo by K. W. Kenyon). Bottom: Removing an adult from a pod of pups during tagging operation; St. Paul Island 1962 (photo by R. D. Bauer).

tained 94.55 cows," an estimate which is surely two or three times too high.

On 4 October 1947, 173 seal pups were weighed. The means were, for males 13.9 kg; for females, 12.0 kg. In a period of 3 mo, the pups had increased to approximately 2.5 times their newborn weight.

1948

The year 1948 marked an important breakthrough in population studies. On the mornings of 14 and 15 July, in brilliant weather, Scheffer and Kenyon flew over all of the Pribilof rookeries in a twin-engine land plane equipped with an F-56 camera with an 8.5-in lens. They photographed the rookeries from directly above, at elevations of 900 to 1,200 ft (275 to 365 m), and at a ground speed of about 90 mph (145 km/h). On photo enlargements, Kenyon estimated the area occupied by breeding animals and pups on each rookery. From counts made on foot the following year of the number of pups on six sample rookeries, he extrapolated to the total number of pups born in 1949, or 580,000 (Kenyon et al. 1954:26-29). This estimate resembled five others obtained by other means, ranging

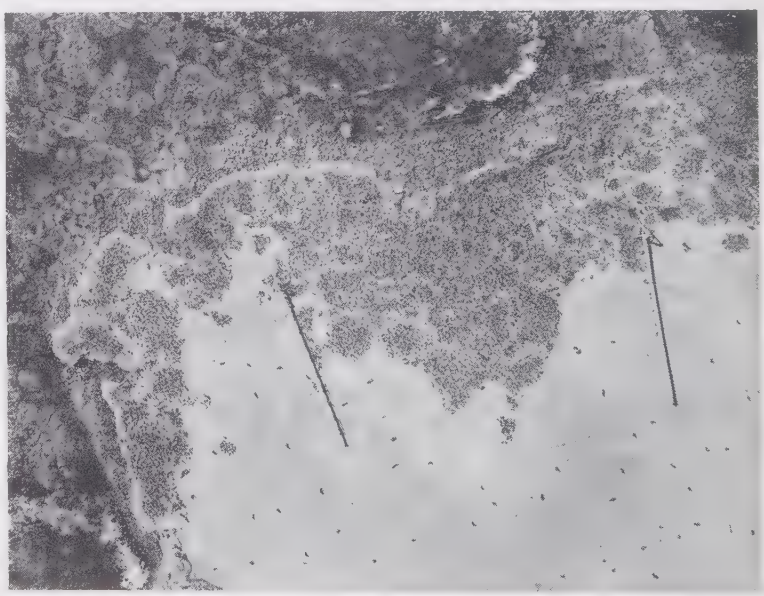

Figure 9.—Top: An attempt to photograph Polovina Rookery from a captive-balloon camera 30 June 1947. Left to right: Raul Vaz Ferreira, Karl W. Kenyon, William H. Sholes, Jr., and Robert Z. Brown (photo by V. B. Scheffer). Bottom: A scene from the first comprehensive aerial photographs of the Pribilof rookeries: Polovina Point, 15 July 1948, from 1,200 feet (photo by V. B. Scheffer and K. W. Kenyon).

from 440,000 to 590,000 pups (Kenyon et al. 1954:1). It differed from an estimate of 1,131,567 pups obtained by the "official computation" method and last published for the year 1947. We will return later to a discussion of the important population studies carried on from 1948 to 1952.

In a memorandum to the Washington office[13] (August 1948), Superintendent Edward C. Johnston wrote that he had photographed all Pribilof rookeries. "The regular series, negative nos. 1-132 inclusive was taken on St. Paul Island, July 15-19 and on St. George July 21-24, 1948. . . . The equipment used was a 5 × 7 inch Press Graflex. . . . In the absence of any information regarding the taking of this series since 1925, it was found advisable to add a number of new photographic stations. . . ."

Some of the Pribilof rookeries were photographed on 28 July 1949 from a U.S. Air Force (B-29) long-range bomber. Kenyon recalls seeing the aircraft high overhead at St. Paul; it did not land, and was said to have returned to a base in Louisiana. The photos were not sharp; only two were saved.

The body of a premature seal pup weighing only 3.5 lb (1.6 kg), or one-third the normal weight of a newborn, was found on St. Paul Island on 16 July 1948. It was pink and sparsely haired. After the biologists became aware of premature pups, they saw many of them each summer. One collected on 11 August 1949 weighed 4.3 lb (2.0 kg) and was still alive though weak. A premature pup may (?) represent abnormally long delayed implantation.

The question of how long a bull seal may remain on his breeding territory without food was partly answered in 1948 when a St. Paul Islander, Lavrenty Stepetin, kept almost daily watch over several bulls near Observation Rock. One remained 54 d, another 59 d, before quitting. Kenyon (1960:437) later obtained better information. For 10 marked bulls, the days spent on harem guard were: minimum 47 d; maximum at least 64 d; mean (of 9 bulls) 54.5 d. The physiology of the fasting bull, particularly his water economy, has never been studied, though Enders suggested as early as 1940 that such a study would be desirable.

In 1948 a yearling seal was killed and preserved by freezing. Later, in Seattle it was X-rayed. The radiographs were donated in 1957 to the Osteology Room of the British Museum. Other radiographs of seal body parts have been made from time to time, e.g., the flipper (Scheffer 1962, plate 111 B) and the genital tract (Peterson and Reeder 1966). Keyes used radiography in 1964 and in later years to study the effect of metal tags upon vital parts of the flippers.

A five-man research team from Harvard University, including Fred Alexander and William S. Laughlin, visited the Pribilofs in 1948 to study the Aleut-speaking people (Anonymous 1948). Alexander made an electrocardiogram of a fur seal pup; Laughlin blood-typed 27 seals and collected blood samples.

In 1948 and 1949, blood serum from fur seals was collected on St. Paul Island and sent to Alan A. Boyden, Director of the Serological Museum of Rutgers University. In later years, when a centrifuge was available, blood samples were collected on several occasions (Blumberg et al. 1960; Fujino and Cushing 1960; Leone and Wiens 1956).

Airmail service was inaugurated to St. Paul Island on 1 November 1948; tourist flights on 2 July 1949. Fouke Fur Company employees were first flown to St. Paul Island on 26 June 1950.

The *Black Douglas* left Seattle on 2 November 1948 on her third and last cruise of fur seal research. With biologists Kenyon and Scheffer, she went to the Pribilofs and back to Unalaska. On 26 November, she headed southeast across the stormy North Pacific, arriving at San Francisco on 6 December. The biologists saw seals almost daily during the 10-d run, some of them 1,000 mi (1,600 km) from land (Wilke and Kenyon 1954:434). Kenyon shot and recovered a seal off the Farallons on 12 December—the only fur seal collected during the pelagic sealing regime of the *Black Douglas*.

Meanwhile, in 1948 a plan was shaping up in Tokyo for pelagic research in waters off Japan. Japan had surrendered to the Allied Forces on 2 September 1945. A Natural Resources Section of GHQ-SCAP (General Headquarters, Supreme Commander for the Allied Powers) immediately undertook to study the natural resources of Japan and to assist in their restoration. Its Wildlife Branch was activated on 4 September 1946 (Austin and Wilke 1950:30). Ford Wilke was sent by the U.S. Fish and Wildlife Service to study the migration and food habits of seals wintering off Japan. He started operations in December 1948 on a "tsukimbosen," a small, peculiar Japanese craft also known as a harpoon boat, or a porpoise-and-seal hunting boat. He collected one seal in December and 21 others in January to March 1949, at which time pelagic research was called off (Austin and Wilke 1950:36-37; Wilke 1951:3-4).

Wilke and two Japanese biologists resumed pelagic studies from 15 March to 31 May 1950 on the *Geizan Maru* during which time they collected 453 seals (Wilke 1951). The 1950 expedition is historically important because it set a pattern for the many expeditions which were later carried out by scientists of the four North Pacific nations. Among the research accomplishments in 1950 were the following: 1) The wintering population off Japan was estimated to be at least 125,000 seals, of which one-tenth to one-fiftieth were of Pribilof origin based on tag recoveries and the assumed Asiatic rookery populations. This was startling news. 2) Of 51 females judged on the basis of tooth-ridge counts to be 3-yr-olds, none was pregnant. Upset was a long-held belief, namely, that the female is impregnated for the first time at the end of her second year. 3) Northern fur seals, regardless of origin, were shown to be indistinguishable and hence referable to a single species, *C. ursinus*. The main evidence was obtained by comparing the skulls of 151 seals collected off Japan with those of 105 seals from Alaska, all females at least 4 yr old. 4) Seals were found to be feeding on small schooling lanternfishes (55% by volume of stomach contents) and squids (44%). No evidence was found to substantiate Japanese claims that seals were feeding heavily on salmon and other commercially important species.

1949

We return to research on the Pribilofs. In 1949, George Colin Lawder Bertram, of Cambridge University, visited the Pribilofs. He came with experience in pinniped research in Antarctica and elsewhere (Bertram 1940). His thoughtful suggestions on research were stimulating to the American biologists.

In July 1949 a useful technique was discovered by accident (Scheffer 1950c). Scheffer had extracted and cleaned the teeth

[13]U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C.

of a bachelor seal and was about to photograph them when he noticed four ridges on the root of each large tooth. Could these correspond to the age of the seal in years? Upon examination of known-age teeth, the answer was "probably." A visit was made to a refuse heap where, a year earlier (15 July 1948), the carcasses of the Reef kill had been dumped. From the teeth of 178 skulls, the composition of the kill was estimated to be: 2-yr-olds, 2%; 3-yr-olds, 68%; 4-yr-olds, 29%; and 5-yr-olds, 1%. This posthumous evidence supported a hunch that 4-yr-olds were contributing substantially to the annual kill. Annual ridges up to about the sixth can be counted on the surface of the seal's tooth. In the late 1950's, biologists Abegglen, Fiscus, Roppel, and Wilke perfected a sectioning technique by means of which at least 26 annual layers can be counted (Fig. 10).

The age composition of an annual kill as determined by tooth-ridge counts was first published for the St. Paul season of 1950 (Kenyon et al. 1954:17). It was first published in routine reports of the fur seal industry for the season of 1954 (Thompson 1956:64). In a parallel table, Thompson gave the age composition as estimated from body lengths. The two tables were quite different, the teeth indicating a 3-yr-old kill of 64%, the lengths, 90%. Reporting of the annual kill by body length was discontinued with the season of 1956.

It was becoming clear that the tables compiled by Hanna in 1913-20, showing the relationship between age and body length of male seals, could no longer be used to estimate age. Scheffer (1955) concluded that in the three decades since Hanna's time, while the seal population had increased 4.3 times, the average size of the individual had decreased as a result of what we may call "crowding." He compared the branded, known-age seals of Hanna's time and the branded or tagged seals of the period 1941-52 with respect to body weight, field length, skull length, and skull width (Fig. 11). "Of fifteen comparisons based upon four age groups (three to six years) and four measurements . . . nine point to a significant decrease in mean body size at the 1 percent level and three at the 5 percent level. For three comparisons, the differences are not significant" (Scheffer 1955:499). Nagasaki (1961:29-33) carried the study further, comparing body size of Pribilof seals in 1952 with that in 1958-62. A downward trend in size was apparently continuing.

Figure 10.—Top: Ancel M. Johnson removing the snout of a female seal for age estimation from the teeth, St. Paul Island, 8 August 1961 (photo by V. B. Scheffer). Bottom: Stanley B. Phillips grinding seal teeth, preparing to estimate age from growth-lines in the roots, 7 October 1963 (Photo by V. B. Scheffer).

Figure 11.—Top: Aleut foreman John Hanson measuring a seal on Reef killing field, 25 July 1946. Measuring was discontinued at the end of 1961 (photo by V. B. Scheffer). Bottom: Weighing a known age (tagged) 9-yr-old male seal on the Reef, weight 415 lb, 1 July 1949. Left to right: Robert Dickerman and Karl W. Kenyon (photo by V. B. Scheffer).

The term "group," to designate male seals in a certain body length range, was introduced by Kenyon et al. (1954:15). "Group III," for example, included seals 41 to 45¾ in (104 to 116 cm) in length, a group formerly known as "3-year-olds." At the end of the 1961 season, the practice of measuring body length was abandoned.

While studies of the tooth-ridge technique were under way in 1949, a parallel investigation was being made of ways to estimate the age composition of the kill from skin weight and from baculum size. (The baculum method had been tested briefly in 1944.) For two kills that included about 3,000 males, the freshly blubbered skins of 1,000 were weighed and the cleaned bacula of 1,000 were measured. The results suggested a bimodal distribution, i.e., two important age classes in the kill, but could not be satisfactorily analyzed. Further study was dropped.

On 2 July 1949 at Northeast Point, 5,329 sealskins were taken, a record kill for any single day in the 20th century.

The area occupied by breeding seals on all rookeries had been measured the previous summer (1948). Now, to obtain an estimate of the area occupied by one pup, the biologists counted, on 9-11 August, live and dead pups on six sample rookeries on St. Paul Island: Lukanin, Kitovi, Polovina and Little Polovina, Morjovi, and Zapadni Reef. They counted live pups partly by making them run the gantlet and partly by scanning groups from a high vantage point. They counted dead pups by walking over the six rookeries and adjacent hauling grounds, dropping a pinch of lime on each carcass (Fig. 7 bottom).

Up to 1949, population studies of the seal herd had been carried on by biologists with limited training in methods of statistical design and analysis. In fact, wildlife research in the United States was only then entering the computer age; in this respect lagging behind agricultural research. In 1949, Z. William Birnbaum, director of the Laboratory of Statistical Research at the University of Washington, kindly agreed to look at a sample fur seal problem. He applied Pearson Type III curves (Kendall and Stuart 1965:152) to the kills of "3-year" (actually Group III) males in 1938 and 1948, and estimated that the postseason escapements were, respectively, 15.4% and 18.3%. One of Birnbaum's staff, Douglas G. Chapman, became chief consultant to the fur seal program in 1950.

The pregnancy rate in fur seals had always been regarded as 100%. At the request of the biologists, the St. Paul Island agent conducted a kill of 100 female seals on 27 October 1949. He shipped to Seattle the frozen genital tracts and teeth. Biologists fixed half of the tracts in Formalin and half in Bouin's solution and forwarded them to Anita K. Pearson, then working with Enders at Swarthmore College. Of the 100 seals, 1 was a 2-yr-old; the others were 4-yr-olds or older.

From gross examination of the uterine horns, Kenyon concluded that 83 of the 99 had borne a pup in 1949. Later, Pearson wrote that, from examination of ovaries as well as horns, 93 had borne a pup. And on 13 May 1950, Harry May (Fouke Fur Company) sorted the salted, blubbered skins of the cows into two piles: 92 "nursing" skins and 8 "nonnursing" skins. It was perhaps coincidental that Pearson and May found similar pregnancy rates. Scheffer examined the skins along with May and concluded that some borderline skins could not surely be identified as those of nursing individuals. At any rate, the 100-cow kill of 1949 produced evidence, later to be amplified, that the overall pregnancy rate is < 100%, over a period of several years (Abegglen and Roppel 1959, table 2, p. 76).

Special kills on St. Paul Island to provide female reproductive tracts were again made in 1951 and 1952. In the meanwhile, tracts or reproductive records were coming into the laboratory from seals killed accidentally during the regular seasons of 1950-52, from seals killed by natives at Sitka in 1950 and 1951, and from seals taken at sea during the 1952 pelagic investigation. By the time Kenyon had assembled his data at the end of 1952, he was able to show that, in 894 females sampled in their fourth year or later, the mean pregnancy rate was 69% (Kenyon et al. 1954:34).

Among endoparasites which he found in seal viscera sent to him in 1949, John T. Lucker, Bureau of Animal Industry, U.S. Department of Agriculture, said that he found filariid worms, hitherto unknown from the fur seal. They were larval forms in a spleen and could not be identified. Microfilariae were next observed in blood of a fur seal killed in the Seattle Zoo on 7 February 1958. Anderson (1959) concluded that slender, thready worms from the testicular sheath of a fur seal were similar to, if not the same as, *Dipetalonema* (= *Filaria*) *spirocauda* (Leidy, 1858), hitherto known only from the harbor seal, *Phoca vitulina*.

We note for the record that the seal tags used in 1949 were mistakenly stamped "CS", for C Series, whereas a simple "C" had been ordered.

1950

The year 1950 opened with outstandingly the coldest, snowiest month in the 60 yr of Washington State climatic records. The emaciated bodies of 29 tagged yearling fur seals were recovered from Washington-Oregon beaches in January and February, suggesting that about 700 tagged as well as untagged yearlings had stranded there (Scheffer 1950b). Here was evidence that exposure and starvation may be important factors in juvenile mortality among seals. On 3 February 1950, Kenyon and Scheffer flew in a U.S. Coast Guard airplane (PBY-5A) from Port Angeles, Wash., to the California-Oregon border and back to look for any unusual distribution of seals as a result of the cold weather. From an altitude of about 200 ft (60 m) they counted 85 seals, mostly solitary, mostly along the edge of the continental shelf. They saw no dead seals.

Early in 1950, plans were made to tap a new source of research information, namely, pelagic sealing by aborigines. The main objective was to investigate the pregnancy rate of females killed on their winter feeding grounds. A sample taken here should, in theory, be more representative of the female class than one taken on the Pribilof "maternity wards." Throughout history, aborigines living along the west coast of North America have been privileged to hunt fur seals by primitive methods. The "aborigines" (Aleuts and Indians) are no longer primitive and they rarely exercise the privilege of sealing. We have mentioned that fur seal stomachs were purchased in the 1930's, from Indians of La Push, Vancouver Island, and Sitka.

Between 24 March and 1 April 1950, Kenyon collected stomachs, genital tracts, fetuses, and other parts, as well as measurements, from 41 seals killed by Tlingits in Crawfish Inlet, 25 mi from Sitka. He found that all seals were adult females and that 31 (76%) were pregnant. The stomach contents were

almost 100% Pacific herring. Only one early fetus of the Pribilof fur seal had previously been known. Kenyon's trip brought to light 31, some of which were later used in describing fetal pelage and dentition.

A positive correlation between size of fetus and size and age of mother was clearly indicated. Pelagic collections since 1950 have repeatedly confirmed this relationship. So far as we know, however, no one has studied the relationship between size of the newborn and size and age of the mother.

Kenyon documented, perhaps as fully as it will ever be, the Tlingit methods of sealing (Kenyon 1955). An Indian fisherman told him that "in shallow water, about 30 fathoms [55 m], a fur seal will swim along a line and rip strips of skin from hooked fish" (Kenyon 1952:246).

The next winter, Wilke went to Crawfish Inlet and examined 107 seals taken by natives between 16 and 27 January 1951. Again all were adult females and again the stomach contents were over 99% Pacific herring (Wilke and Kenyon 1952). Wilke collected here the first series of adult skulls for taxonomic comparison with those of Asian seals (Wilke 1951:12). After the 1951 Sitka expedition, no further attempt was made to exploit aboriginal sealing for research purposes. The international pelagic research programs launched in 1952 provided a better way to obtain information.

The summer of 1950 on the Pribilofs was a busy one. Kenyon and others made a full-scale test on all rookeries of the "reconnaissance" method of estimating pup populations. During the last 14 d of July, living pups were estimated on both islands. (For St. George Island, this was the first pup count since 1924.) Dead pups were counted individually on most of the rookeries and were estimated by reconnaissance on the others. The reconnaissance technique was tried again in 1951 and never thereafter on a large scale. The results obtained in 1950-51 seem to have been well within the limits of possibility, however, and the technique should perhaps be restudied.

The 1951 totals were (Kenyon et al. 1954:29, with corrected arithmetic):

	Living pups	*Dead pups*	*All pups*	*Percentage dead*
St. Paul Island	280,400	76,300	356,700	21.4

Extrapolated to the Pribilof Islands on the basis that the St. Paul harem bull count is 0.829 of the Pribilof count, the number of pups born in 1951 was about 440,000.

The highest pup mortality, 39%, ever estimated for a rookery was on Polovina in late August 1950 (Kenyon et al. 1954, table 12, p. 31).

In 1950 the returns from the first all-out tagging program were studied. In 1947, 19,183 pups of both sexes had been marked with A-series tags. In 1950 there were recovered 1,264 A-tagged 3-yr-old males, representing 13% of those tagged (Kenyon et al. 1954:71). The first estimate, by the Petersen-index method, of a fur seal year class indicated that 530,000 pups were born on the Pribilofs in 1947 (Kenyon et al. 1954:22).

It was also the first estimate based on tooth-ridge counts, rather than body length, as an index of age. Daily throughout the killing season on St. Paul Island 20 right upper canine teeth were analyzed.

A crude hut (blind) was erected above Kitovi Amphitheater on the site of the present concrete structure, and photographs of the rookery were taken at 5- or 10-d intervals from 15 May to 27 September 1950. The results were useful in 1952 to George A. Bartholomew when he studied the Kitovi Amphitheater harems in detail (Bartholomew and Hoel 1953). The results also showed that all harem bulls were on station by early July. This in turn led, in 1951, to an advance of 5 d in the starting date of the annual bull count (Thompson 1954:61). By starting on 10 rather than 15 July, the counting crew now has more leeway before the late July breakup of harems.

In 1950, 100 fur seal hearts and 100 salted, dried diaphragms were sent to the Bureau of Animal Industry Laboratory at Beltsville, Md., to be examined for filariid worms and trichinid worms. None was found.

The testes of about 150 seals, ages 3, 4, and 5, and those of about 20 bulls were preserved in Bouin's solution and sent to Richard G. Blandau, of the University of Washington School of Medicine, in 1950 and 1951. His findings were summarized by Kenyon et al. (1954:49-50). Evidently sperm formation may begin in a few precocious 3-yr-olds but is not routine until the fifth year. All healthy bulls, whether "idle" or "harem" are evidently producing sperm throughout the summer. No study of male fecundity has subsequently been made.

During the killing season of 1950, Kenyon weighed the testes of 222 tagged 3-yr-olds.[14] He reasoned that, because older males arrive on land in summer ahead of younger ones, the sexually more mature members within an age class may arrive ahead of the sexually less mature ones. He found, however, no important difference in testes weights of earlier arriving and later arriving males, as follows:

Date killed	*Number of seals*	*Mean and range of weights (g)*
17-28 June	90	27.93 (9-74)
22-26 July	132	27.03 (10-78)

The 3-yr-olds were screened for size by the killing crew. If a random sample of 3-yr-olds had been taken it might have shown the effect that Kenyon postulated.

The bacula of a few known-age seals collected in 1950 were sectioned and stained by a technician at Providence Hospital, Seattle. The slides did not show evidence, as had been hoped, of annual growth layers.

Kenyon and Scheffer identified the sex of 1,000 seal pups on St. George Island on 4 August 1950 and found 505 males to 495 females. (Ten years later, Niggol (1960) reported that the ratio in 6,729 fetuses and pups was 51.7% males.)

On 3 October 1950, Kenyon supervised the killing of 100 female seals on Northeast Point Rookery. He sent the genital tracts to Oliver P. Pearson and Anita K. Pearson. The Pearsons had worked with Enders and were now continuing their studies of mammalian reproduction at the University of California. The Pearsons' report (1950)[15] confirmed the fact of delayed implantation in the fur seal.

[14]Kenyon, K. W. 1950. Analysis of tagged 3-year-old fur seal tested samples, 1950 kill. Unpubl. manuscr., 2 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[15]Pearson, A. K., and O. P. Pearson. 1950. Delayed implantation in the northern fur seal. Unpubl. manuscr. Northwest and Alaska Fish. Cent., Natl.

On 20 December 1950, the Fish and Wildlife Service contracted with the University of Washington for the part-time statistical advice of Douglas G. Chapman. Essentially the same contract has been kept alive down to the present.

The second Alaska fur seal bred and born in captivity saw light in the San Diego Zoo on 20 July 1950. It was a male and on 22 July weighed 9¼ lb (4.2 kg). It died of an unknown ailment on 7 September 1950, at which time it weighed about 28 lb (12.7 kg).

After the breakup of the Fur Seal Treaty in 1941, the United States and Canada entered into an executive agreement in 1942 to regulate sealing in the northeastern Pacific; this agreement was renewed in 1947. By public statement in Tokyo on 12 June 1951, Japan agreed to prohibit pelagic sealing, pending the conclusion of a new fur seal treaty (Anonymous 1951).

By 1951, plans were being laid by the United States to draw the four nations of the North Pacific again into a fur seal convention. In a memo of 16 April 1951, William C. Herrington, of the State Department, proposed an international study of the migration, numbers, and food habits of fur seals. The study got under way in the next year, 1952, when the peace treaty with Japan was also signed.

1951

While the need was recognized in 1951 for renewed studies of the Pribilof herd, funds were short and the Fish and Wildlife Service conducted only a modest program of research that year. The old, unsatisfactory laboratory on St. Paul Island was still in use. Its facilities were overcrowded in summer by five collaborators and visiting scientists, namely: George A. Bartholomew (University of California at Los Angeles), who studied seal behavior; O. Wilford Olsen (Colorado Agricultural and Mechanical College), who launched the first of an annual series of hookworm studies; Raymond Aretas (Office de la Recherche Scientifique d'Outre-mer, Laboratoire des Pêches et Productions Coloniales, Museum d'Histoire Naturelle, Paris), an observer; Karre Rodahl (Arctic Aeromedical Laboratory, Ladd Air Force Base, Fairbanks), who studied infection known as "spekkfinger"; and William L. Jellison (U.S. Public Health Service), who was interested in parasites and diseases of wild animals and man (Bartholomew and Hoel 1953; Olsen 1958; Aretas 1951; Rodahl 1952, 1953; Jellison 1951[16], 1952; Jellison and Milner 1958).

Wilke had served in the old Food Habits Laboratory of the Fish and Wildlife Service. During the summer of 1951 on the Pribilofs he noted fur seal "spewings" on the beaches, as well as numerous fish otoliths (ear bones) which had resisted weathering of the spewings. He and Kenyon collected otoliths and found that all were from codlike fishes up to a foot long: *Theragra chalcogramma*, *Gadus macrocephalus*, *Microgadus proximus*, *Boreogadus saida*, and *Eleginus gracilis*. He tentatively concluded that "fur seals depend to a large degree on small fishes of the family Gadidae during their stay in the Bering Sea" (Wilke and Kenyon 1952:397).

In 1954, Kenyon pursued further the idea that information on food habits might be obtained on land. Little attention had been given to the stomachs of seals on land, for it was known that they were usually empty. Kenyon had the sealers slit open the stomachs of 50,239 seals and he found that about 1 in 1,500 contained appreciable food remains. The remains were 94% by volume Pacific sandfish, *Trichodon trichodon*, and 6% sturgeon poacher, *Agonus acipenserinus*. Neither species had previously been recorded as fur seal food (Kenyon 1956).

Funds being short, only 1,000 seal pups were tagged in 1951. On 100 of the pups, half of the left ear was clipped off. (Ear clipping had last been tried in 1924.) No clipped seals were seen later, probably because the sample was too small.

In 1951 for the first time a plot of breeding ground was marked off as a counting area for estimating pup mortality during summer. The rate started at zero on the 1st of July, reached a peak in late July, and dropped to zero in mid-August.

In O. W. Olsen's first summer on the islands, he examined 722 animals, mostly fur seals and sea lions (O. W. Olsen 1951[17]). He found hookworms in the intestines of many fur seal pups, but in no older seals, though he examined several hundred 2-yr-olds and older. The over-winter reservoir of the hookworm was to remain a mystery until 1961. Olsen or one of his graduate students, Carl F. Dixon, Dale R. Masters, or Eugene T. Lyons, was on the Pribilofs each summer from 1951 to 1962, with the exception of the 3-yr period 1956-58.

The biologists and G. A. Bartholomew collaborated in taking the temperature of 322 seals. "The bulls and cows at rest have a mean deep body temperature of 37.7°C [99.9°F]. Pups have a mean rectal temperature of 38.2°C [100.8°F]. Body temperatures may [under stress] rise as high as 43.9°C [111.0°F], but temperatures higher than 41.5 [106.7°F] are found only in animals incapacitated by heat exhaustion" (Bartholomew and Wilke 1956:336).

Wilke collected a sample of fur seal milk in 1951 for analysis and found that it was 46.0% fat (Wilke 1958). Two samples were taken from a female in estrus, about 6 d after parturition.

On 19 July 1951, Kenyon photographed several breeding and hauling grounds from a U.S. Navy helicopter at altitudes between 20 and 300 ft (6 and 90 m). The flight was on an overcast day between 2:15 and 3:00 p.m. The aircraft threw the seals into a panic and, though the photographs were reasonably sharp, Kenyon concluded that the method was unsatisfactory.

We have mentioned Bartholomew's 41-d study of seal behavior in 1951 at Kitovi Amphitheater. It is historically important as the first attempt to use statistical methods for determining the time relationships of reproduction in the fur seal. Important results (mean parameters) are listed below (Bartholomew and Hoel 1953):

Mean date of the pupping season (half of the pups born), 16 July.
From arrival of the female to parturition, 2 d.
From parturition to estrus, 6 d.
Departure for sea after onset of estrus, 1 d.
Duration of first trip to sea, 5 d.

Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[16]Jellison, W. L. 1951. Sealer's finger or speckfinger. Unpubl. manuscr., 4 p. U.S. Public Health Service, Rocky Mountain Laboratory, Hamilton, MO 64644.

[17]Olsen, O. W. 1951. Report on investigations of hookworms, *Uncinaria lucasi* Stiles, 1901, and hookworm disease of fur seals, *Callorhinus ursinus*, on the Pribilof Islands, Alaska from July 7 to September 2, 1951. With supplementary report by W. L. Jellison. Unpubl. rep., 98 p. Colorado State University and U.S. Fish and Wildl. Serv., Denver, CO 80521.

Duration of stay ashore between trips to sea, 2 d or less.
Size of average harem, 39.
A female copulates only once a season.

Bartholomew discussed in two other papers (Bartholomew 1953, 1959) other aspects of fur seal behavior.

The ailment "spekkfinger" (seal finger, blubber finger) was tentatively identified for the first time on the Pribilofs in 1951 when Rodahl and Jellison examined a hard, persistent swelling on the finger of a temporary biologist. The ailment is uncommon here and is disappearing from sealing areas over the world as a result of improved sanitation. Svenkerud et al. (1951) proposed to call the causative organism *Corynobacterium phocae.*

"*Salmonella enteritidis* was isolated from blood and viscera of 5 and 12 sick fur-seal pups . . . during the late summer of 1951. Lice from one of the pups . . . also harbored *S. enteritidis.* Salmonellosis may contribute significantly to mortality of seal pups" wrote Jellison and Milner (1958:200).

The Three-Nation Investigation of 1952

Canada, Japan, and the United States agreed in 1952 to launch a joint investigation of the distribution and food habits of northern fur seals (Taylor et al. 1955:ii). The agreement entered into force with respect to the United States and Japan on 8 February, and with respect to Canada on 1 March. "The Soviet Government declined [to join] but expressed an interest in reestablishing international arrangements for the conservation of the seals" (Taylor et al. 1955:1).

Why a new investigation? In 1896 the Jordan Commission had been instructed "to conduct a scientific investigation . . . of the present condition of the fur-seal herds on the Pribilof, Commander, and Kurile islands" (U.S. Treasury Department 1896:5). That investigation and the treaty which followed in 1911 were conceived in desperation, in an effort to save the seals from destruction. In 1952, though the security of the seals was no longer threatened, the question of how best to utilize the herds was faced by the North Pacific nations. Japan had lost her sealing grounds on Robben Island and the Kuriles to the U.S.S.R. in 1945. Intermingling of seal stocks of Asian and North American origin, flatly denied in Jordan's time, was now confirmed and was suspected of being important. The people of Japan now numbered about 90 million and their demand for food fish had risen greatly; the extent of predation by seals on commercial fish was a correspondingly greater concern. Pelagic sealing by Japanese during World War II had reduced the Commander Island's herd, though to what new level was unknown. These and other considerations lay behind the joint investigation of 1952.

"Two expeditions were, therefore, organized in February 1952. One using six vessels operated off the coast of northeastern Japan from 19 February to 17 June; the other using two vessels off the coast of North America. The latter investigation was divided into two parts, the first operating off California, Oregon, and Washington from 8 February to 30 April and the second off Alaska from 4 June to 13 July. All three Nations took part in the investigations off Japan, but Japan was unable to participate in the investigations off North America. The vessels hunted in waters important in pelagic-sealing days. Seals were killed with shotguns and were examined by biologists with respect to presence or absence of a tag or marks, the sex, age (determined by tooth-ridge counts), stomach contents, body length and weight, and length and weight of fetus when present" (Taylor et al. 1955:2). Off Japan, 2,329 seals were taken and off North America, 686. The principal biologists in charge were: for Canada, Fred H. C. Taylor (western expedition) and James I. Manzer (eastern); for Japan, Fukizo Nagasaki; for the United States, Ford Wilke (western) and Victor B. Scheffer (eastern).

The investigation showed that three nations can jointly explore the biological bases for a treaty. It provided North American biologists with a chance to develop a pelagic sealing technique which they were later to use on many occasions. Listed in order of importance, the main findings of the investigation were as follows: 1) Seals of Pribilof origin composed about 30% of the seals in waters off Japan in spring. (The small sample taken in 1950 had indicated 10 to 25%.) 2) For every age class, the pregnancy rate was higher in Asian than in North American seals. Weighted to reduce sampling errors, the overall rate for Asian seals was 80%; for North American seals 68%. A large part of the difference has been explained by assuming that Asian seals mature earlier than do North American seals. This assumption was first published in 1964 (North Pacific Fur Seal Commission 1964). "A comparison of samples from the eastern and western Pacific shows that female groups of mixed origin in the western Pacific have a pregnancy rate of approximately 50 percent in the fourth year, and those mostly of Pribilof origin from the eastern Pacific have a rate of approximately 50 percent in the fifth year" (North Pacific Fur Seal Commission 1964:10). "A consistent difference of one year in the age of reproductive maturity" was reiterated by Pike et al. (1965[18], p. 3). 3) Of the stomach contents of seals taken off Japan, 31% (by volume) represented species of some commercial value; off North America, 36%. The main prey species off Japan were lanternfishes and squids, 87% by volume. Many kinds of fishes and squids were taken off North America. Before 1952, almost nothing was known about the food habits of seals south of Washington State. 4) In a comparison of skull measurements of 523 female seals 6 yr old or older, it was concluded that seals from Asian waters and North American waters are indistinguishable. Similar results were obtained from a covariance study of body length against condylobasal length. Wilke (1951) had anticipated this finding, though on the basis of a smaller sample. 5) Pregnant females were found to be longer in body and to have heavier teeth than nonpregnant females of the same age. This phenomenon could mean that larger (and stronger?) individuals tend to have a higher pregnancy rate or it could mean that gestation brings changes in the vertebral column and teeth. 6) Over 400 fetuses were measured and weighed. On the basis of those taken in North American waters, Chapman was able to estimate that "the mean date of implantation is quite certainly in early November" (Scheffer 1962:9).

The joint investigation was carried out in 1952; the report did not appear until 1955. As Kenyon wrote (in letter of 6 May 1954) "the area of disagreement among biologists of the three countries is very small but because the report has been examined in the light of its political implications complete agreement is difficult to reach." The release of the report in 1955

[18]Pike, G. C., I. B. MacAskie, and A. Craig. 1965. Report on Canadian pelagic fur seal research in 1964. Unpubl. rep., 16 p. Fish. Res. Board Can., Pac. Biol. Stn., Nanaimo, B.C. V9R 5K6 Can.

coincided with a growing, worldwide interest in marine mammals, and the printing of 1,000 copies was soon exhausted.

The U.S. biologists were busy with pelagic research in 1952 and had little time for studies on the Pribilofs. However, "Approximately 20,000 pups were tagged on St. Paul Island in September. Data were obtained on animals tagged in previous years, studies were resumed on the reproductive success of the herd, and pup mortality was again recorded" (Thompson 1954:53).

The biologists embalmed two seals and sent them to a biological supply house, which injected them and forwarded them to Robert B. Chiasson, University of Arizona. Chiasson (1955a) used them for a doctoral dissertation on the anatomy of the seal. He used photographs of cross sections of another seal. A 50-lb (23 kg) bachelor, frozen in 1952, was shipped to Seattle and was cut with a band saw transversely into 14 2-in (51 cm) discs (Fig. 12 top). In addition to his thesis, Chiasson published two papers on seal dentition (Chiasson 1955b, 1957).

Two seal pups were flown to the Seattle Zoo and a patch was shorn from the silvery pelage of each on 24 November 1952 (Scheffer 1962:27). The regeneration of guard hair and underfur was noted at intervals until the captives died in 1953 and 1954. The experiment gave evidence on the duration of molt, about 15 wk. Similar studies, though incomplete, were carried out on four bachelor seals in 1954 and an adult and a subadult female in 1957. The two pups captured on the Reef on 22 November 1952, shipped to Seattle in an aluminum dog crate, and placed in the Seattle Zoo on 24 November, were the first seals sent by air from the Pribilofs.

The historical period which we have termed "establishment of continuous research" closed in 1951-52 when a deadline was drawn on the inclusion of new material in Kenyon et al. (1954:4). In that report all useful evidence, old and new, on the age and sex composition of the herd was reviewed. While better evidence has since been obtained, the report is useful in describing the population structure at the end of a 40-yr management regime in which only males were cropped. It is also valuable in presenting the first life tables for male and female seals based on known-age stock (Kenyon et al. 1954:38, 40).

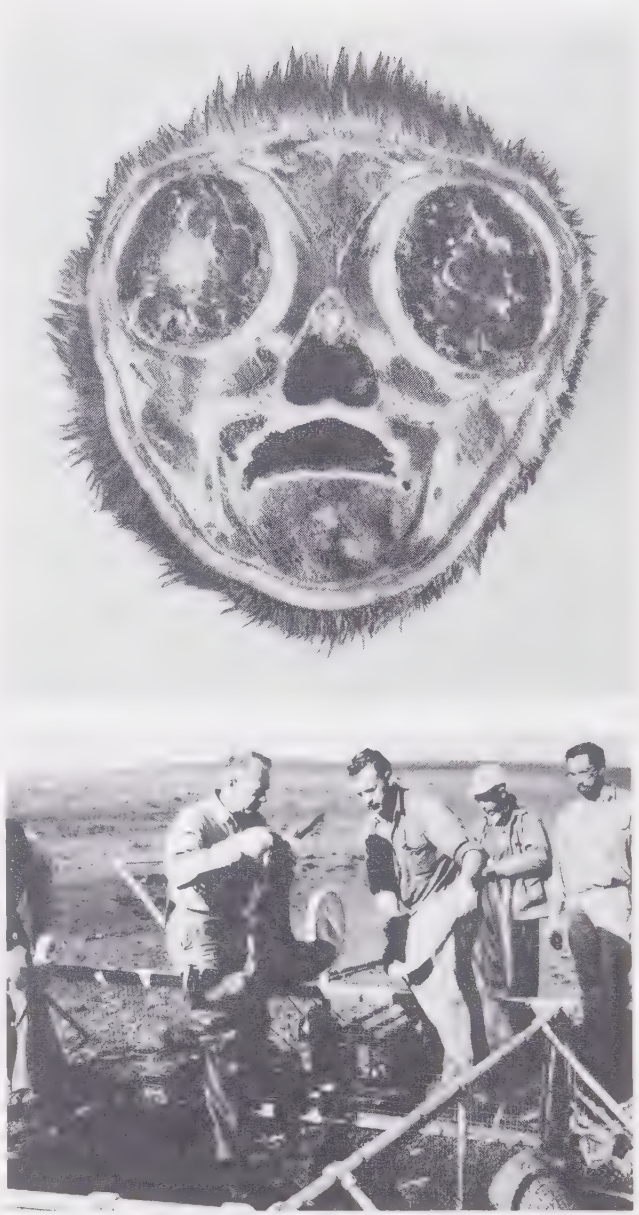

Figure 12.—Top: Section through the head of a bachelor seal killed on 21 August 1952. The carcass was frozen and cut into 2-in thick discs from snout to tail for study of anatomy (photo by V. B. Scheffer). Bottom: Weighing seal pups on St. Paul, 1962; Ford Wilke at left with pup (photo by R. D. Bauer).

Studies in the Harvesting of Female Seals, 1953-57

1953

In the early 1950's, biologists concerned with the Pribilof herd realized that it had ceased to grow, yet they were uncertain what changes to recommend in harvesting practice to meet the new situation. They agreed that release of population pressure was called for. One thought was to increase the kill of males by 6 or 7% per annum. Another thought, and the one which was translated into action, called for the killing of females. This proposal would both reduce the herd and correct a possible (?) imbalance of sexes. Steady pressure from the Japanese Government to reduce the herd was still being felt, as it had been in 1941 when the United States cropped an extra 30,000 males. Furthermore, the joint investigation of 1952 had shown that the pregnancy rate of Pribilof seals was low. If due to a low ratio of males to females, some argued, then killing of females would be desirable.

The idea of killing "sacred cows" met resistance at first from the Aleut inhabitants, steeped as they were in the traditions of the islands, and from Fouke Fur Company employees who considered the subadult male Government Alaska Sealskin a "gold standard" among furs. Females were first deliberately killed in 1953 on an experimental basis. The most in a single year, 47,413 were killed in 1957. After 1963 the kill was held to a sustained annual level of about 18,000.

Between 15 June and 4 September 1953, Wilke supervised the experimental killing of 607 females on St. Paul Island rookeries (Thompson 1955:61, 72). He and Robert Krear selected specimens at random, killed them by .22-rifle fire, and dragged them to one side of the rookery. The kill was useful in two ways: it showed that "harem raiding" is a poor way to harvest females and it produced the first good evidence on age, pregnancy rate, and body size among rookery females throughout an entire sealing season.

Also in 1953 on St. Paul, 244 females were killed accidentally during regular male kills; many of these were examined by Wilke. (Females were not killed intentionally with males until 1954.) Comparisons given below illustrate some interesting results of Wilke's studies in 1953.

In age composition the rookery sample of females clustered around years 5, 6, and 7; the hauling ground sample around years 4, 5, and 6. (The following figures are reworked from Wilke 1953[19], table 10.)

	Number	*Percentage killed of each age*								
Area	*killed*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*10+*
Rookeries	551	3	6	14	15	10	8	8	6	30
Hauling grounds	164	3	16	49	19	5	2	0	1	5

A similar relationship was confirmed many times in later studies (North Pacific Fur Seal Commission 1964, table 9).

With respect to pregnancy rates, Wilke (footnote 19, p. 23) found that they average 89% for rookery seals and 67% for hauling ground seals. A similar relationship was confirmed later (Abegglen and Roppel 1959:78-79). He also noted that, of 34 rookery 4-yr-olds, 23% were pregnant, while of 27 hauling ground 4-yr-olds, only 7% were pregnant. We do not know that the discrepancy has ever been explained.

Wilke (footnote 19, table 8) observed a strong tendency for females to arrive on the rookery in reverse order of age, the oldest in early July and the youngest in late August. He also noted (his table 2) that, within an age class, the heaviest females tend to arrive earlier on the rookeries and hauling grounds than do the lightest. The difference in weight between the first and the last arriving groups was about 12%. (Excluded from the samples were females obviously pregnant, i.e., with near-term fetus.)

In summer of 1953 Robert W. Rand, an observer for the Union of South Africa, visited the Pribilofs (Rand 1955). He was at that time engaged in studies of the biology and management of the South African fur seal, *Arctocephalus pusillus*.

The Fouke Fur Company had started before 1950 to experiment with brine curing of sealskins to replace conventional dry salting. By 1953, about two-thirds of all skins taken were brined, and within a year or so all were brined (Thompson 1955:61). In 1953, the Company experimented with a beaming machine to replace blubbering by hand. It proved to have little value because of the individual variation in thickness and elasticity of skins.

Scheffer transferred to headquarters[20] in Colorado in September 1953 and returned to the Marine Mammal Biological Laboratory in July 1956.

A seal exclosure was built on Vostochni Rookery in May 1953 to test whether hookworm larvae could move horizontally through soil. Exclosures of one kind or another are common research tools of the wildlife biologist. The Vostochni structure may represent the first to be used for a marine mammal.

While North American "aborigines" even today have a treaty right to hunt fur seals pelagically, they have taken almost none since 1953. The high point in aboriginal sealing had been reached in 1925, when the natives took 6,412 seals, representing 24% of the Pribilof harvest for that year (North Pacific Fur Seal Commission 1964:31).

1954

Female seals, as well as males, from 41 to 45 in (1.0 to 1.1 m) in length were deliberately killed in the drives of 1954. This was done with the expectation of harvesting 5,000 females without disturbing the rookeries. Plans fell short; only 658 females were taken (Thompson 1956:53, 64). Evidently this number represents about all that can be taken when seals in conventional drives are killed for size but not for sex.

O. W. Olsen had found that hookworm larvae survive over winter in great numbers on the rookeries, even under ice. He had found in laboratory studies that certain chemicals will kill larvae in soil. In early summer of 1954, therefore, nematocides (coal tar derivatives) were sprayed over 6.2 acres (2.5 ha) of rookeries on St. Paul Island. None reduced the pup mortality caused by uncinariasis (Kenyon 1954:4[21]; Dixon 1955:23[22]; Thompson 1956:56). The count of dead pups continued to rise. It was about 20,000 in 1941 on both islands and it reached 111,000 in 1954 and 120,000 in 1956.

Dead seals older than pups were counted in 1954 on St. Paul Island for the first time since the 1890's. The totals were 221 males and 423 females, or fewer than 1% of the population.

In the work plan for the summer of 1954 is a statement that "specimens of diseased skin" were to be obtained for Cleveland J. White, of Chicago. In answer to an inquiry, Dr. White replied (in letter of 3 July 1964): "According to my record, I found an injurious fungus *Trichophyton gypseum* (= *T. mentagrophytes*) on slides, both on microscopical examination and, of course on Sabaraud's medium . . . I did not publish the findings."

In the years between 1940 and 1955, before pup tagging started on St. George Island, search was often made for tagged seals on breeding grounds there. If it could be shown that seals born on one island rarely take up breeding stations on another island only 40 mi (66 km) away, then it could be argued that few Pribilof seals "defect" to Asian islands. Up to the end of 1954, wrote Kenyon (footnote 21, p. 26), only one St. Paul seal, a bull, had been seen on a St. George rookery.

Kenyon studied the wandering of pups on land in late summer. Ten thousand had been tagged on 7-10 September 1954. On 20-21 September, 236 tagged pups were rounded up on five rookeries; only 14 pups (or 6%) were found to have strayed from home.

He marked 30 bulls with white paint in 1954 and observed their territorial movements (Kenyon 1960). He found that bulls tend to choose their territories in early summer without regard to locations most likely to be selected by the first arriv-

[19]Wilke, F. 1953. Alaska fur seal investigations, Pribilof Islands, Alaska, summer of 1953. Unpubl. rep., 34 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[20] Cooperative Wildlife Research Unit, U.S. Fish and Wildlife Service, Colorado State University, Ft. Collins, CO 80521.

[21]Kenyon, K. W. 1954. Alaska fur seal investigations, Pribilof Islands, summer of 1954. Unpubl. rep., 48 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[22]Dixon, C. F. 1955. Report on the fourth summer of investigations on hookworms, *Uncinaria lucasi* Stiles, 1901, and hookworm disease of fur seals, *Callorhinus ursinus* Linn., on the Pribilof Islands, Alaska, from May 31 to September 7, 1954. Unpubl. rep., 36 p. U.S. Fish Wildl. Serv., Washington, D.C.

ing females. Displaced bulls return stubbornly to their former stand. Early arriving bulls stay on station for an average of 54 d.

Two museum studies were published (King 1954; Sivertsen 1954) both of which illustrated and compared the skulls of northern (*Callorhinus*) and southern (*Arctocephalus*) genera of fur seals.

1955

In 1955, as in the previous year, female seals were killed for size in regular male drives; 726 were taken (Thompson 1957:79).

By 1955 the mass of research data including tag numbers recovered from seals, body measurements, and information on reproductive condition, had grown to the point where it called for automatic data processing. Simple Keysort cards were used at first, and in 1957 the IBM system was adopted.

Tagged in 1955 were 49,870 pups, more than ever before in 1 yr. The aim was to provide a better statistical base for estimating the size of the Pribilof population and the degree of intermingling of North American and Asian seals. Over an 8-yr period, 50,000 to 60,000 pups, representing 6 to 10% of those born, were tagged annually. The tagging slacked off in 1963 when evidence of tag-induced mortality was first recognized. Approximately one-fifth of the tags applied in 1955 bore the serial letter "H", while four-fifths did not.

"In an attempt to learn more about fur-seal feeding habits and in particular to determine the effect of the seal population on salmon feeding in or passing through waters in the vicinity of the Pribilof Islands, the [biologists] in 1955 captured 204 fur seals at sea" (Thompson 1957:69-70).

"In the stomachs of 117 fur seals . . . capelin was the dominant food near the Aleutian Islands (52 per cent of total food by volume) and was replaced offshore by squid and Alaska pollack which there made up 47 per cent of total food by volume. Salmon . . . and sand lance each appeared once" (Wilke and Kenyon 1957:238). The seals were collected from the *Paragon*, the first time that a halibut schooner had been used for pelagic fur seal research.

Fukuzo Nagasaki, of the Japanese Fisheries Agency, spent 6 wk in 1955 on St. Paul Island as an observer. He was later to figure prominently in fur seal treaty meetings.

1956

From 28 November 1955 to 9 February 1957, the North Pacific Fur Seal Conference alternately met and recessed. It was successfully concluded, and in 1958 a four-nation research program got under way. We will discuss this later. In the meanwhile, during Conference discussions, the objective of "maximum sustainable productivity" of the fur seal herds was often discussed. In line with this objective, the United States made an effort in 1956 to reduce the size of the Pribilof herd. Females were deliberately killed, the length standards for males were raised in order to provide more large animals, and the killing season was extended into September. When the season closed, 122,826 skins had been taken; the greatest number harvested on land since the uncontrolled season of 1868.

Details of the kill were given by Thompson and Erickson (1960:69-70). Females were picked up from hauling grounds and rookeries throughout the season. Many seals were picked up from grounds not ordinarily visited by the sealing gang; all were killed, as usual, by club. "Harem raids" were again made as in 1953, though on a much smaller scale. Hundreds of skins were found to be stagy (molting) in August and September.

The herd reduction program continued for 8 yr, through 1963. During this period the mean annual kill of females was 33,745 (4,315-47,413), while the mean annual number of female skins saved for the market was 27,336 (4,296-47,423) (Roppel et al. 1963:1, 1965b:1, 17; North Pacific Fur Seal Commission 1964:85; Power 1964:11). That is, 81% of the skins were used.

During the 1956 kill, a record was kept for the first time of the color of the whiskers (vibrissae) of females (Abegglen et al. 1956:82[23]). The purpose was to find an age index which could quickly be spotted on the killing field. The 5-yr-old (entering 6th year) was found to exhibit the greatest variability in color; most younger seals having black whiskers, most older ones white.

Scientific studies of the fur seal received new emphasis in 1956. Biologists Carl E. Abegglen and Alton Young Roppel joined Wilke on the permanent research staff (Abegglen left in 1962). During the summer of 1956 the new laboratory on St. Paul Island was occupied for the first time. On St. George Island, a small laboratory was set up in the hospital, pup tagging was initiated, and a summer biologist was first assigned to the island. In winter, the Seattle research headquarters were moved from Edmonds to Sand Point Naval Air Station. "Biological research" attained the status of a separate chapter in the annual report of the Pribilof fur seal business (Thompson and Erickson 1960:72). The Bureau of Commercial Fisheries was established as a component of the Fish and Wildlife Service by a law which became effective on 6 November 1956 (70 Stat. 1119 (1956); U.S. Congress, House 1958:156-160).

More tooth samples were collected in 1956 than ever before. The sample quota was raised to 10% of males and 20% of females. Biologists extracted, cleaned, and counted layers on the right upper canine of about 7,000 males and 4,000 females. By 1964 the sampling schedule for males had become routine, as follows: "10 percent of a kill of 300 or more; 20 percent of 100 to 300; and 30 percent or more of 100 or fewer animals" (Roppel et al. 1965a:3).

The mortality of pups on land was high in 1956, partly because lactating mothers were killed throughout the summer. The count of dead pups by 26 August was 119,505 (including a 5% markup for pups overlooked). This is still the highest count on record; it represents a mortality of 12% (North Pacific Fur Seal Commission 1964, tables 12, 16). It is a conservative estimate, for pups continued to die after 26 August, especially from starvation.

About 46 man-days were spent in making the count on both islands. To simplify the task in the future, 10 sample plots representing about one-third of the pupping area on St. Paul Island were delineated. Most of the plots were marked with

[23]Abegglen, C. E., A. Y. Roppel, and F. Wilke. 1956. Alaska fur seal investigations, Pribilof Islands, Alaska. Report of field activities June-September 1956. Unpubl. rep., 145 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

permanent signs reading "Research Area." Through 1964, dead pups were counted outside, as well as inside, the plots.

At the end of 1956, after two summers of experimentation, large scale soil treatments for the control of hookworm were abandoned. They were found ineffective, for a reason that we will explain later.

A temporary employee on St. George Island in 1956 set up a blind near the center of North Rookery and made periodic observations of adult male seals (McGilvrey 1957). He was on watch about 3 h daily during the "pre-breakup" period from 30 June to 27 July, and during the "post-breakup" period from 28 July to 24 August. During the first period he saw only one harem bull ousted by an idle bull. During the second period, however, 8 out of 10 matings were effected by idle bulls. He concluded that a management policy which provides for equal numbers of idle and harem bulls at the height of the season in mid-July will insure impregnation of all females in estrus.

1957

In April 1957, Karl Niggol joined the staff of the Marine Mammal Biological Laboratory to take charge of pelagic research, a position which he held until he left the Laboratory in 1962. Gary A. Baines started work as a temporary assistant in June 1957, joined as a permanent biologist in 1962, and resigned in 1964. Clifford Hunter Fiscus joined the pelagic research team in 1958 and became its leader in 1962 when Niggol left.

Leo P. Doyle, Professor Emeritus of Veterinary Science, Purdue University, spent the summer of 1957 on St. Paul Island. Through examination of about 1,800 dead pups, he appraised the causes of mortality such as physical injury, inherited defects, starvation, and hookworm anemia. "Would these causes eventually change in relative importance as a result of the herd reduction program?" he asked. Doyle studied the "before" aspects in a before-and-after kind of investigation; the "after" aspects are still being studied. The reduction program ended with the killing season of 1963.

Doyle concluded (1957:9[24]) that "injuries and starvation were responsible for most deaths . . . before 15 July. After 15 July, hookworm infestation was more important. Many pathological conditions were found but only a few were common. Hookworm, emaciation, ruptured liver, and head injury each caused 10 percent or more of the deaths amoung the pups . . . *Salmonella enteritidis* was isolated from one of 58 pups examined bacteriologically." Wilke found that the body temperature of a seal pup, especially one in weakened condition, may drop sharply during a rainstorm. In 18 dying pups the rectal temperatures were from 65.1° to 78.4°F, (18.4° to 25.8°C) whereas the normal temperature is 100.8°F (38.2°C). Doyle also found in seals the ubiquitous *Escherichia coli.*

J. L. Hamerton, of the British Museum (Natural History), found a "diploid chromosome number of almost certainly 2n = 36" in fur seal spleen (letter of 17 December 1957). A seal pup on St. Paul Island in July 1957 was treated with colchicine to initiate mitosis. About an hour later, it was killed and its spleen removed. Spleen and bone marrow tissues from an adult female killed at the Seattle Zoo on 7 February 1958 were also sent to Hamerton. (The female had miscarried a few days previously.)

We believe that fur seal blood samples were taken in 1957 for George J. Ridgway, Pacific Salmon Investigations of the Fish and Wildlife Service. Others were taken for him the next summer.

Twelve hundred pups were weighed in late August 1957 on St. Paul Island in the first of a series of measurements of "condition factor" (Fig. 11 bottom). It was hoped that evidence obtained over a span of years would enable the biologists to correlate body condition in late summer with survival 3 and 4 yr later. At the end of 1964, however, biologists wrote that "Preliminary studies are not encouraging" (Roppel et al. 1965a:22).

Tagged pups, male and female, proved to be lighter than untagged ones. Here was unpleasant evidence that tagging induces mortality and that it must be taken into account in any population computation based on tag recoveries.

Stainless steel trays with 100 compartments were put into use during 1957 for cleaning right upper canine teeth. A "half snout" was placed in each compartment on the killing field; a cleaned tooth was later removed from each compartment in the laboratory.

As an index of reproductive condition, the presence or absence of milk in the mammary glands was recorded for most females killed in 1957 and 1958. It proved to be a poor index, since it depended largely on individual judgment. It was not used after 1958.

In their population report, Kenyon et al. (1954) had not discussed the homing tendency of seals, though they had given a breakdown by rookery of the number of A-tagged males returning as 3- and 4-yr-olds in 1950-51 (Kenyon et al. 1954:71). Nagasaki and Matsumoto (1957) analyzed the data further and developed equations. They showed that the kill on a particular rookery included from 51 to 81% native males, where 20% would be expected on the basis of chance alone.

All recent annual reports of research on the Pribilof Islands have included tables on homing. For example, Roppel et al. (1963:24) gave tables on homing according to age, sex, and rookery of birth. The mass of information on homing tendency accumulated since 1951 has not been summarized.

The Four-Nation Investigations of 1958-64

The long-awaited North Pacific Fur Seal Conference opened in Washington on 28 November 1955. Representatives of Canada, Japan, the U.S.S.R., and the United States met to negotiate a treaty to replace the one which had been in force from 1912 to 1941. On 9 February 1957, an Interim Convention on Conservation of North Pacific Fur Seals was signed; it came into effect on 14 October 1957 (U.S. Congress, Senate 1957; North Pacific Fur Seal Commission 1958[25], 1964). Its main provisions are listed below.

[24]Doyle, L. P. 1957. Investigation of death losses in fur seal pups on St. Paul Island, Alaska, June 28 to August 15, 1957. Unpubl. manuscr., 10 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[25]North Pacific Fur Seal Commission. 1958. Report of first meeting, January 13th to 17th, 1958. Unpubl. rep., 18 p. North Pac. Fur Seal Comm., c/o Natl. Mar. Fish. Serv., NOAA, Washington, D.C. 20235.

1) Pelagic sealing was prohibited except for research purposes. A recommendation was to be made at the end of the fifth year (14 October 1962) as to the best methods of sealing. Behind this provision lay Japan's hope that the best method would prove to be pelagic sealing, and that she would again be permitted to take part directly in cropping the North Pacific Fur seal resource.

2) A 6-yr cooperative research program (to 14 October 1963) was set up to determine the measures necessary to achieve maximum sustainable productivity.

3) The seal harvests were to be shared. Of the U.S. harvest from the Pribilofs, 15% was to be delivered to Canada and 15% to Japan; of the Soviet harvest from her islands, 15% to Canada and 15% to Japan. (As a result of a 1963 amendment, the U.S.S.R.'s contribution was reduced to 10% for the 3-yr period 1964-66.)

4) A four-man commission was established. The North Pacific Fur Seal Commission was organized and held its first meeting in Washington on 13-17 January 1958. The commissioners were George R. Clark, Kenjiro Nishimura, Alexsandr A. Ishkov, and Arnie J. Suomela. (Mr. Clark died in 1963.)

Figure 13.—Harold L. Hansen weighing a seal aboard the MV *Windward*, 1960 (photo by Pelagic Section, NMML).

1958

Early in 1958 the joint research program got under way. For 6 ensuing years the biologists of Canada, Japan, the U.S.S.R., and the United States studied abundance, distribution, and food habits of seals at sea. Simultaneously, biologists of the two nations which own seal islands—the U.S.S.R. and the United States—continued to study seals on land. Some of the studies on land and sea were prescribed by the Convention; some would have been carried on in its absence.

United States biologists chartered two halibut schooners and one purse seiner and took 1,503 seals off the west coast of North America (Wilke et al. 1958[26]) (Fig. 13). A section of the Marine Mammal Biological Laboratory in Seattle was converted to a "wet lab" where seal stomach contents could be analyzed and where seal teeth could be sectioned. Fiscus gradually built up a reference collection of fishes and invertebrates, plus a few marine birds and mammals, for use in identifying remains in stomachs. The task of identifying partly digested remains on the basis of such hard parts as bones, otoliths, scales, eye lenses, and beaks is not easy. Fortunately, the remains in seal stomachs are usually schooling fishes and the identification of one specimen leads to quick recognition of others.

An improved technique for estimating the age of a seal from the right upper canine tooth was developed in 1958 (Wilke et al. footnote 26, p. 10-15). Charles M. Kirkpatrick (Purdue University) had shown in an unpublished report in 1957 that longitudinal sections reveal growth layers more clearly than do surface ridges. In the pelagic research report for 1958 (Wilke et al. footnote 26, table 4) there was given the first breakdown of ages beyond 10 yr from a sample of teeth. The oldest of 1,321 females was 22 yr. David F. Riley made a photographic study of teeth in 1959. Scheffer in 1962 examined sections of the lower jaw and found that the bone is reworked during life, eventually obscuring the pattern of annual layers. Fiscus examined lower canine teeth in 1963 and concluded that they are less useful than upper teeth for routine age estimation. Today, the so-called "aging method" is essentially the one developed in 1958.

"An 11-year-old female, carrying two well-developed, equal-sized female fetuses, was taken on 9 May 1958, furnishing the first record known to the United States of twins in the northern fur seal" (Wilke et al. footnote 26, p. 2) although there was one earlier report (Johnston 1925). Later, Niggol and Fiscus (1960) summarized information on four sets of twins. The two observed combinations were: same sex and different uterine horns, different sexes and same horn.

We will not dwell on the yearly pelagic programs after 1958, since they are summarized in the report of the North Pacific Fur Seal Commission (1964). This report covers the first 4 yr of the 6-yr investigation; it was issued in order to give the Commissioners time to study it before they were called upon to draft an extension (protocol) of the Convention. The report contains an enormous amount of information in its text and 137 tables. It is the best modern reference to statistics of the northern fur seal herds.

While the 1958 pelagic program was under way, research continued on the Pribilof Islands. Gordon Pike and Fukuzo Nagasaki visited St. Paul as official observers for Canada and Japan, respectively, under terms of the Convention. Biologists of the Marine Mammal Biological Laboratory completed their second summer of training under general manager Clarence L. Olson in the technique of counting bulls. In 1959, the biologists assumed responsibility for the count.

For the first time, a seal marked on the western side of the Pacific was recovered on the eastern side. At Northeast Point on 16 August 1958, a 6-yr female seal wearing a Commander Islands tag was killed.

The design of the U.S. tag was improved by moving the serial number to the upper, or clinching, side where it is less subject to wear. Five thousand pups were double tagged as a

[26]Wilke, F., K. Niggol, and C. H. Fiscus. 1958. Pelagic fur seal investigations/ California, Oregon, Washington, and Alaska, 1958. Unpubl. rep., 96 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

check on percentage of tag loss. Three years later, in 1961, it was found that the probability of one tag being lost was 67%; of both tags, 3%. In 1960, the lettering "Washington, D.C." was replaced by "Seattle, Wash."

In 1958, Maynard Murray, of Chicago, asked the Bureau of Commercial Fisheries to obtain 50 lb (23 kg) of fur seal thymus. "We are investigating whether or not the thymus in a seal atrophies after puberty as it does in many land mammals. The answer . . . would be critical in our (cancer?) research" (letter of 16 June 1958). In September 1958, Scheffer collected various bodies from the ventral thorax of 13 seals and sent them to Murray; none proved to be thymus. An entire newborn pup collected in July 1959 and preserved in Formalin was later sent to Murray. The project was dropped after 1959.

A curious relationship between high air temperature on St. Paul Island in January to March and low pup mortality on land the following summer was discovered by Abegglen in 1958. It was examined further by Roppel et al. (1963:40) who showed on the basis of 12-yr data that "The mean air temperature for St. Paul Island . . . 1 July to 30 June, and the total count of dead pups in the following August continue to show a significant inverse relationship [which] cannot be explained."

In 1958, whole blood or blood serum samples were collected from fur seals at the request of four individuals: B. S. Blumberg, Kazuo Fujino, George Ridgway, and H. R. Wolfe. Two of these later published on results of their studies (Blumberg et al. 1960; Fujino and Cushing 1960). Wolfe had earlier published on serology of pinnipeds other than fur seals (Pauly and Wolfe 1957). A brief resume of Ridgway's findings was placed in the unpublished annual report for 1958 (Abegglen et al. 1958:53[27]). Much work remains to be done on fur seal blood. Eventually we may be able to identify the birthplace of a seal, at least its native island, through blood analysis. Fujino and Cushing (1960) found that "individual variations exist in the erythrocyte antigens of fur seals" collected off Japan in the spring of 1958. In a total of 234 blood samples they found nonrandom distribution of types, "suggestive that some localization of breeding stocks is maintained within the winter population from year to year."

A small-scale study of the quality of skins taken from females on land was launched in 1958. It represented an effort to evaluate skins new to the fur trade, namely, those of older females. According to Abegglen et al. (1959:39[28]) the skins of 248 known-age females collected on St. Paul Island in August 1958 were graded by the Fouke Fur Company. The percentages of "Regulars" (Fines, One's, and Two's) were as follows:

Body length							
(in)	40	41	42	43	44	45	46-52
(cm)	102	104	107	109	112	114	117-132
Percentage regulars	57	64	46	56	34	34	22

The study demonstrated the rapid dropoff in quality of larger skins from older animals. About 24 of the skins were rejected in routine processing. All skins processed by a new shearing technique (later known as Lakoda) were finished satisfactorily.

For the record, we give a brief account of the origin of the shearing technique. In the fall of 1957, Lavrenty Stepetin killed 10 tagged yearlings on St. Paul Island, primarily for their known-age teeth. He sent the skins to the Marine Mammal Biological Laboratory. One of them was forwarded to the New Method Fur Dressing Company (San Francisco), where the pelage was sheared near the outer level of the fur. "This unusual treatment is a test of utilization of fur sealskins having poor quality fur" (entry in BDM catalog under specimen no. 511). On 24 February 1958, the Laboratory sent the sheared skin to Ralph C. Baker (Central office, U.S. Bureau of Commercial Fisheries), who forwarded it to the Fouke Fur Company for examination. The Company filed a patent claim on 18 March 1959 for the shearing process (Pingree 1961). The first sheared skins, under the Fouke trade name "Lakoda," were sold in October 1960. "It seems obvious," wrote Baker in a letter of 13 June 1962 to the Directory of the Bureau of Commercial Fisheries, "that the idea of shearing sealskins came to Mr. Pingree after they received the sheared skins sent to them by the Bureau of Commercial Fisheries." (Pingree may have seen only the one skin, or he may have seen others, since the New Method firm sheared other specimens for the Laboratory in the spring of 1958.) The word "Lakoda" is derived from "lakudaq—fur of a sea-bear; female seal pup (Pribilof Island dialect)" (Geoghegan 1944:113).

Two studies of pelage anatomy and histology were carried out between 1957 and 1961. The first resulted in a general description of the pelage (Scheffer 1962); the second in a calendar of molt stages according to age and sex (Scheffer and Johnson 1963). In the latter study, the investigators were surprised to find that fur fibers accumulate in the skin with age; a silver pup has about 15 per bundle and an old adult over 50. They also found that only three-fourths of the guard hairs molt annually. During the study, the mammary gland-complex was dissected for the first time. It is very large, reaching from the fore flippers to the heels (Scheffer 1962:54-55).

Seals with abnormal pelage known as "rub" are frequently seen on land and at sea. Over the rubbed area the guard hairs are absent or sparse, and the fur fibers are snarled and matted (Scheffer 1962, pls. 77B, 78, 79). Pelage specimens from the two adult seals illustrated in Scheffer's plates were sent frozen and in Formalin to a Public Health Service laboratory in 1958. Robert W. Menges reported (in letter of 2 March 1959) that neither specimen showed evidence of ringworm or sarcoptic mange. The origin of "rub" is still a mystery.

Population estimates made by Chapman on the basis of 8 yr of tag returns between 1950 and 1957 contained unresolved discrepancies; Chapman (1958:65)[29] concluded that new

[27]Abegglen, C. E., A. Y. Roppel, and F. Wilke. 1958. Alaska fur seal investigations, Pribilof Islands, Alaska. Report of field activities, June-September 1958. Unpubl. rep., 187 p. Northwest and Alaska Fish. Cent., Natl. Mar Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[28]Abegglen, C. E., A. Y. Roppel, and F. Wilke. 1959. Alaska fur seal investigations, Pribilof Islands, Alaska. Report of field activities, June-September 1959. Unpubl. rep., 132 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[29]Chapman, D. G. 1958. Population estimates of Pribilof fur seal pups based on 1957 data. *In* C. E. Abegglen, A. Y. Roppel, and F. Wilke, Alaska fur seal investigations, Pribilof Islands, Alaska. Report of field activities, June-September 1958, p. 65-82. Unpubl. rep. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

studies of the tag-estimation procedure were needed. This seems to have been the first realization that unknown factors (such as tag-induced mortality?) were causing bias in the annual Petersen-type estimates.

At various times over an 8-yr period, adult female reproductive tracts were collected on the snowy Pribilof Islands during November and December. They were examined without success for early embryos. Finally, on 3 December 1958, three out of five adults taken on St. Paul Island contained implanted embryos, the largest embryo being only 20 mm long (Scheffer 1960b; Abegglen et al. footnote 28, p. 20). A proper study of fur seal embryology is still to be done. Material must be collected at sea in winter, a time when pelagic sealing is difficult and dangerous.

David E. Sergeant (Fisheries Research Board of Canada) drew plans in 1958 for transplanting Alaskan fur seals to certain islets off northeastern Newfoundland (in letter of 5 October 1964). He later decided that southern fur seals (*Arctocephalus* sp.) would be more promising subjects since they do not migrate far from their breeding grounds.

1959

The sealing season of 1959 brought a shock—the take of males was only 30,195, the smallest since 1927. Was the new policy of killing females responsible? Biologists argued two points to dispel this idea: 1) Only 10,000 males of the class of 1956 appeared in drives in 1959 when 30,000 had been expected. In 1956 the first large killing of females took place. Of 27,599 killed, about 12,700 had born a pup that summer (Abegglen and Roppel 1959, table 2). If all of the male pups, or 6,350, had lived to enter the 1959 harvest, the harvest of 3-yr-olds would still have been 13,650 short of expectations. 2) The count of dead pups on land in 1956 was the highest on record. Were the survivors in poor body condition when they set out to sea and, as a consequence, did few return to contribute to the harvest of 1959?

The season of 1959 brought widespread realization that survival of individual year classes in the Pribilof herd would fluctuate widely as long as the herd remained close to the limiting factors in its environment. Harvest management would be improved if a method of forecasting the size of the harvest could be developed. Ways of predicting the size of a 3-yr class were discussed by Chapman (1959)[30] among them the following: 1) Counting dead pups and weighing live ones each summer. Both would provide evidence of the general welfare—the start in life—of the current year class. 2) Studying the kill of 2-yr-olds. Over a period of years, a relationship between the kill of 2's in one year and 3's the next might be calibrated. A trial prediction was made in 1960; the results were as follows:

Kill of 3-year males on St. Paul Island, 1961

	Predicted	*Actual*
Kill through 31 July	19,000	29,523
Kill through 7 August	34,500	40,172

3) Studying the early season kill of 3-yr-olds. The kill for the first 15 d would indicate the probable take for the season. This method was tried in 1959. The forecast for St. Paul Island was 9,469; the actual take was 10,494. Such a short-term forecast can never be of much value; it nips too close to the heels of the fact. 4) Studying the weather records for St. Paul Island. The belief was held for a while that, when the mean annual temperature for year X ending 30 June is high, the return of 3-yr males in year $X + 3$ will be high (Abegglen et al. 1961:15[31]). 5) Studying the pelagic take of males, by year class, at ages 1, 2, and 3, in advance of the land take. For example, if the class of 1960 contributed strongly to the pelagic take of yearlings in 1961, of 2-yr-olds in 1962, and of 3-yr-olds in early 1963, it would presumably contribute strongly to the land take of 3-yr-olds in later 1963 (Abegglen et al. footnote 31, p. 39-41).

The low harvest of 1959 suggested that crowding in the fur seal population causes increased fluctuation in survival rate of the young. Chapman (in Abegglen et al. footnote 31, p. 71-73) pointed to another demonstration. For the period of 1947-55 he showed that the proportion of returning bachelors tended to vary inversely as the size of the year class. That is, when the number of male pups estimated in September was high, the fraction returning 4 yr later was low, around 10-11%. When the number estimated was low, the percentage was high, around 26-28%. (Not only the proportions, but the absolute numbers, of returning 4-yr-olds varied with the pup estimates.) Chapman's correlation has not been challenged in principle, though some of the figures he used in 1959 have been adjusted in the light of recent information.

It is advisable at this point to discuss a paradox: 1) A high count of dead pups in 1956 was used to explain a low return of bachelors in 1959. 2) A high count of dead pups means poor survival into September and consequently a low estimate of living pups at time of tagging. 3) A low estimate, according to Chapman's correlation, means a high return of bachelors. The explanation: A high count of dead pups is important as an indicator of a weak class—one which will experience severe mortality later at sea. A high count of dead pups is relatively less important as a factor in the September pup estimate, for dead pups make up only a fraction of the total class. The relationship under 1) above is therefore determining.

Fur seal biologists for a decade or more have wondered "Is mortality equal for the sexes up to age 3 or 4?" Today the evidence points to a higher rate for males. The evidence began to accumulate in the late 1950's when the herd-reduction program first brought in hundreds of tagged adolescent females, as well as males. As early as 1959, however, Karl Niggol had made a "search for sex disparity in fetal death rates" (Niggol 1960:428). He argued that, if the mortality during gestation shifts measurably in favor of the survival of one sex, then we might conclude that the trend persists in the yearlings and 2-yr-olds, both of them classes which are difficult to sample. Niggol tabulated the sex ratios of 3,081 fetuses by 10-d periods during the last 6 mo of gestation. The ratios were re-

[30]Chapman, D. G. 1959. Preliminary report on forecasting the kill of male fur seals on the Pribilofs. *In* C. E. Abegglen, A. Y. Roppel, and F. Wilke, Alaska fur seal investigations, Pribilof Islands, Alaska. Report of field activities, June-September 1959, p. 49-58. Unpubl. rep. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[31]Abegglen, C. E., A. Y. Roppel, A. M. Johnson, and F. Wilke. 1961. Fur seal investigations, Pribilof Islands, Alaska. Report of field activities, June-November 1961. Unpubl. rep., 148 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

markably uniform; they deviated only at random from a mean of 50.9% males.

In 1959, Allison M. Craig (Pacific Biological Station, Fisheries Research Board of Canada) began a study of the reproductive cycle of the female seal with special emphasis on the histology and histochemistry of tissues. She carried on where the Pearsons had left off. Between 1959 and 1964, she examined many hundreds of tracts collected by Canadian and U.S. biologists. Her first report was released in 1963 (Craig 1963[32]). William Shapeero joined the staff of the Marine Mammal Biological Laboratory in 1960 to carry on similar studies. He left in 1961 after a fire destroyed his histological work room.

Live pup counts were made on 5 August 1959 on two sample areas on St. Paul Island rookeries. From high vantage points, 2,147 pups were counted on a portion of Kitovi and 702 on a portion of Tolstoi. The objective was to get a quick estimate of pups without waiting 3 or 4 yr for tag returns. However, by 1963 it was evident that the annual counts were inconsistent. The count for one area might go up and for another down over the same 2-yr span. In 1964, therefore, a new and larger system of study plots was designated; these are still in use (Roppel et al. 1965a:19).

From 1959 to 1962, Scheffer and Bertram S. Kraus (Department of Orthodontics, University of Washington) collaborated on a study of the gross morphology and development of deciduous and permanent teeth of the fur seal (Scheffer and Kraus 1964). They examined the dentitions of approximately 200 fetal and older seals. They found that: "The deciduous teeth are essentially nonfunctional; two-thirds of them are usually shed in fetal life. The permanent teeth begin to calcify very early; all have erupted from the jaw, though not all from the gum, at birth. Root growth continues through life, especially in teeth which retain an open pulp canal for 20 years. The 1st premolar and all molars in each quadrant are primary permanent teeth. A "lower 1st incisor" was presumably lost in the evolution of the seal. Cusplets and a double root on certain teeth suggest that modern teeth are derived from more complex ones" (Scheffer and Kraus 1964:293).

Three of Kraus' students, Bokstrom, Lamb, and Takano, studied fur seal specimens while writing master's theses (see literature cited by Scheffer and Kraus 1964). Kraus transferred to the University of Pittsburgh in 1963.

Annual reports in the series "Alaska Fishery and Fur Seal Industries," started by Barton Warren Evermann in 1911, were discontinued at the end of 1959.

1960

On 1 January 1960, the State of Alaska assumed responsibility for its own fisheries, though the Federal Government continued to manage the fur seal industry.

In 1954, Kenyon et al. (1954, table 15) had published a life table with a summary estimate of 1.3 million female seals alive at the beginning of the year (15 June). In 1960, Abegglen et al. (1960, tables 27-29[33]) erected three new tables with estimates of 1.2 to 1.4 million females. None of the tables proposed thus far is regarded with great confidence; too many factors remain unknown.

Chapman (in Abegglen et al. footnote 33, p. 37) examined tag recovery records, searching for significant runs of one sex. He found no evidence that seal pups segregate themselves by sex at time of tagging.

On 7 August 1960, sealing was terminated by the Government on St. Paul Island, partly on the advice of Fouke Fur Company employees who judged that the proportion of "stagy" skins had reached a critical level. In later discussion it was agreed that a few standard sealskins in critical molt should be processed and sent to the Pribilofs for the future guidance of the men responsible for closing the sealing season. Six skins in advanced molt were accordingly selected by Harry May from the 1961 crop, two of which were sent to St. Paul Island (Marine Mammal Biological Laboratory, File 8.05.01).

At the conclusion of male killings in 1960 the practice of counting "rejects," or animals released from the killing pods, was abandoned. The counts had been made for at least 20 yr but had never been published.

The skulls of 24 bull seals were collected on St. Paul Island in 1960 and were sent to Soviet fur seal biologist Sergei Vasilievich Dorofeev (in 1961). About 1963, bull skulls from Soviet seal rookeries were received in exchange. Dorofeev had proposed to make a systematic comparison of Asian and North American seals. We believe that the project was dropped after his death in 1962.

In 1960 the "first recognized post-partum animal that had delivered twins on land" was killed on Reef Rookery (Abegglen et al. footnote 33, p. 27). She was a 4-yr-old taken in a sealing drive; her pups were not identified. Another female killed was carrying a full term fetus in her abdominal cavity; the placenta was entwined among the intestines. This the only record of ectopic pregnancy.

In the summer of 1960, Chapman visited the Pribilofs in order to familiarize himself with research operations, such as tagging, upon which his statistical analyses for nearly a decade had been based. Upon his return, he was in a position to discuss past and future statistical work with a new appointee to the Laboratory, Ancel M. Johnson. Johnson transferred to Seattle in 1960 from a background of statistical work for the Fish and Wildlife Service in Denver. Chapman also developed "a simple model . . . on the premise that reduced survival [to age 3] is due to pressure on the food supply around the islands which affects the survival of the seal pups in their first year" (Chapman 1961:356). He gave two equations, the results of which were similar, for the relationship between pup population and survival.

Also at the Pribilofs in 1960 were three Soviet observers representing the first U.S.S.R.-United States exchange of visitors as provided for by the Convention of 1957. They were P. G. Nikulin (who had written as early as 1937 about northern pinnipeds), T. K. Kostarnov, and L. V. Kostin. Scheffer visited Robben Island that summer, though too late to see the

[32]Craig, A. 1963. Key to the reproductive condition of female fur seals (*Callorhinus ursinus*) and the reproductive cycle of mature female fur seals. Manuscr. Rep., Biology 754, 25 p. Fish. Res. Board Can., Pac. Biol. Stn., Nanaimo, B.C. V9R 5K6 Can.

[33]Abegglen, C. E., A. Y. Roppel, and F. Wilke. 1960. Alaska fur seal investigations, Pribilof Islands, Alaska. Report of field activities, June-October 1960. Unpubl. rep., 165 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

sealing season (Scheffer 1960[34]). The following year, Wilke and party visited the Commander Islands (Wilke et al. 1961[35]) and in 1963 Wilke visited Robben Island. Wilke (1963[36]) thus became the first American since Stejneger in 1922 to land on the three breeding resorts of the northern fur seal. We will not dwell on international exchanges of personnel after 1960.

W. J. L. Sladen (Johns Hopkins University) began in 1960 a study of upper respiratory infections of Pribilof Islanders. He had been a biologist and medical officer for the Falkland Islands Dependencies Surveys in Antarctica in 1947 and later. His interest soon extended to fur seals; he collected blood samples and biopsies in 1960 and 1961. He isolated *Clostridium perfringens* from seals in 1961; this probably causes enteritis in pups (Keyes 1963). (For further technical details, see Abegglen et al. footnote 31, p. 50, 58.) One of his students, Richard S. Peterson, later made an important behavior study of fur seals on Kitovi Rookery.

In May 1960, Andrine Merculief, a native of St. George Island, found the fresh carcass of a large dog about 500 ft (150 m) inland from Zapadni beach. Small boys had heard a dog barking on the drift ice about 2 wk earlier. Presumably the animal was a sledge dog from St. Lawrence Island or the mainland. The incident shows that Pribilof foxes and seals are not completely insulated from the parasites and pathogens of carnivores from other shores.

Larry R. Nygren (1963) successfully fed a captive pup. "One pup learned to suck warm fur seal's milk from a human baby bottle. The hole in the tip of the nipple had been enlarged to accomodate the thick milk. To my knowledge this was the first successful bottle-feeding involving a captive fur seal pup." Nygren wrote (in a letter of 15 September 1965) that the pup had been taken by caesarean section in late June or early July and was still alive in September.

The first of many attempts to anesthetize or tranquilize fur seals for research purposes was made in 1960 (Abegglen et al. footnote 31, p. 69). The Palmer "Cap Chur Gun," firing a drug-loaded syringe, had been released for sale in 1958 in Georgia. It soon became a popular research tool for wildlife managers. Against fur seals in 1960 it was not a success. Between 1961 and 1964, however, Peterson and Keyes carried on further experiments in immobilizing seals and were satisfied with the results. A report of their successes and failures was not immediately released to the public because of the potential hazard of certain drugs used in the studies (Peterson 1965a).

The crew of a pelagic sealing vessel collected a killer whale near Kodiak, Alaska, in 1960. It was killed with a 50 mm Norwegian harpoon gun mounted on the bow of the vessel. It was the first of a small series of specimens of killer whales and sharks taken in an effort to learn more about the predators of seals. We believe that it was the first killer whale taken for research purposes in North American waters, though several had been taken by commercial shore-whalers. The following summer, a killer was taken off San Francisco. In its stomach were fragments of northern elephant seal, *Mirounga angustirostris*, California sea lion, and a small cetacean.

The pelagic research crew in 1960 obtained evidence that nursing female seals may forage out to 206 nmi (382 km) from the Pribilof Islands. In midsummer in Unimak Pass they collected seals which, upon examination proved to be post partum.

Scheffer (1960a) compared the weights of 10 organs or glands in the fur seal with those in the dog. He found no important differences, though, from the evidence of one sample, the fur seal thyroid is relatively small.

The routine of weighing 1,200 pups each summer had been established in 1957. This was the basis for determining whether body condition at age zero (summer of birth) in autumn is related to survival at the ages of harvest. To measure the variability in body weight at the age of harvest and relate it to the body condition at age zero, a portable scale-and-rule was trundled along the killing fields of St. Paul in 1960 and 1,672 known-age 2-, 3-, and 4-yr-olds of both sexes were weighed and measured.[37] At the end of 1963 the project was abandoned because it produced no meaningful data.

In 1960 the length measurements of pregnant and nonpregnant seals were compared. The data from seals killed on land were inconclusive; those from seals killed at sea in 1958 and 1959 indicated that pregnant animals are longer than nonpregnant ones of the same age. This curious relationship was discovered in the pelagic research of 1952 (Abegglen et al. footnote 33, p. 74).

A test run was made on two small rookeries in 1960 to find the ratio of tagged to untagged pups of the current year class. Workmen removed all dead pups from Zapadni Reef and Little Polovina just before they started the annual tagging operation here. Several weeks later, they examined (for tags) 747 live pups and 278 dead ones. The experiment was encouraging; it was extended in 1961 to all St. Paul rookeries, though dead pups were not removed. It yielded an estimate of 275,000 pups at time of tagging, or definitely fewer than had been estimated in recent years by other means. In the third year, 1962, the estimate was 231,800 pups. Starting in 1963, fall pup sampling was based on individuals especially marked by shearing, rather than on individuals wearing metal tags. The pup sampling trials of 1960-62 were important in focusing attention on the weaknesses of the conventional Petersen-index method based on returns of subadults.

The "Marine Mammal Biological Laboratory" received its name in July 1960. Wilke (1960) summarized information on the life history and exploitation of the northern fur seal. His summary was later incorporated in a more extensive publication by Baker et al. (1963). Gerald J. Oppenheimer, librarian for the University of Washington's Fisheries-Oceanography Library, compiled a list of reference sources for marine mammalogy (Oppenheimer 1960).

In 1960, C. Howard Baltzo became Program Director of a newly formed Marine Mammal Resources Program.[38] Research

[34]Scheffer, V. B. 1960. Observations on Robben Island, U.S.S.R., in summer of 1960. Unpubl. manuscr., 29 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[35]Wilke, F., A. Y. Roppel, and K. Niggol. 1961. Observations on Medny and Bering Islands, Kamchatka, U.S.S.R., in July 1961. Unpubl. rep., 40 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[36]Wilke, F. 1963. A visit to Robben Island, U.S.S.R., in 1963. Unpubl. manuscr., 20 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[37]A. Y. Roppel, wildlife biologist, National Marine Mammal Laboratory, Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115, pers. commun. 1964

[38]Marine Mammal Resources Program, now the Pribilof Islands Program, Northwest Regional Office, Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

and management of fur seals have, since then, been closely coordinated.

1961

A dying, emaciated yearling seal crawled out on the beach at Valdez, Alaska, in January 1961, and a State biologist later autopsied it (Neiland 1961). He found that "it was heavily infected with seven species of helminths." He was first to record trematodes (flukes) from the Alaska fur seal; in fact, he found three species: *Pricetrema zalophi* (Price 1932), *Phocitrema fusiforme* (Goto and Ozaki 1930), and *Cryptocotyle jejuna* (Nicoll 1907). *Phocitrema* sp. had been reported in 1941 from a Commander Islands seal; "fluke eggs" had been found by Doyle (footnote 24) in seal carcasses at the St. Paul Island by-products plant.

In 1961, Delyamure published a long list of marine mammal parasites, including 12 species from *Callorhinus ursinus* collected in the western Pacific and adjacent seas. None of the 12 had been collected in the eastern Pacific through 1964, suggesting that American zoologists have much to learn about the parasites of the Alaska fur seal.

The harvest of bachelor seals in 1961 was very high: 82,197. The poor harvests of the past 4 yr were forgotten; the policy of killing female seals was generally accepted.

The summer of 1961 brought a breakthrough in the long and discouraging study of hookworm. Lyons and Olsen (1962)[39] found that the fur seal pup gets its initial infection through mother's milk. Larvae wintering over in the rookery soil are not essential in the life cycle of the worm.

Olsen (1962:247-250) and Olsen and Lyons (1962) summarized the life cycle of the worm. An egg passed in the feces of an infected pup develops to a third stage strongyliform larva, within its egg case, in rookery soil. In late summer it hatches into a free-living third stage larva. Some larvae penetrate the naked flippers of adult female seals and migrate to the belly blubber and mammary tissue. Others winter over in the soil. (In certain years free-living third stage larvae are hard to find in soil in summer or spring.) During the first few days of lactation, larvae enter the mother's milk and pass into the intestine of the nursling. In about 2 wk, or in the latter half of July, the larvae mature in the lower intestine and enter their most destructive phase. This is the only intestinal phase of the worm; it lasts 4 or 5 mo, or until autumn. Almost no worms can be found in the intestine in September.

An important 3-yr study of the behavior of fur seals on land was started in 1961 by Richard S. Peterson, candidate for degree of D.Sc., Johns Hopkins University. He was attracted to the problem because "fur seals are among the very few mammals in the world whose behavior can be easily observed and documented without disturbance, and [there is] need for knowledge of comparative mammal behavior" (Peterson 1962[40]). He observed seals from a hut on Kitovi Rookery from 1 September to 26 November 1961, from 14 May to 26 November 1962, and from 12 June to 7 October 1963 (Peterson footnote 40, 1963[41], 1964, and in letter of 11 November 1964). He developed new and useful techniques for immobilizing and marking seals, and for defining and categorizing behavior traits. He marked 1,300 seals, concluding that the best method was to shear a pattern in the pelage and follow with a peroxide foam bleach. Sixteen marked bulls holding inland positions on Kitovi Rookery held their stations from 13 to 77 d, with a mean of 47 d (Peterson 1965b:52-54).

Peterson and Reeder (1966:52) described three twin births in the fur seal—"the first descriptions of multiple births among the Pinnipedia." In one case, the mother delivered twins in captivity. Peterson immobilized her, injected her uterus with a radiopaque fluid, and made a roentgenogram which proved that both pups had been delivered from the same horn. The mother recovered and was released with her pups. She later abandoned them. The authors were unable to find any record of a mother having raised two pups to weaning age.

In 1961, yearling seals were tagged for the first time, to get evidence on mortality rates from birth to age 1 yr and from age 1 to 3. The number tagged was disappointingly low; yearlings were hard to find. Fourteen were known-age (tagged as pups), 740 were judged to be yearlings on the basis of size. The sex ratio appeared to be 1 male to 4.3 females, whereas in all previous collections of known yearlings on land in autumn, the males had been more numerous. Suspicion rose that many small females thought to be yearlings in 1961 were actually 2-yr-olds. The following year, "twenty-three animals tagged as yearlings in 1961 were recovered from the kill . . . age determination from canine teeth revealed that only one was a yearling when tagged" (Roppel footnote 37).

The stomachs of four seal pups were examined at St. Paul Island in October 1961. The contents included sandfish, walleye pollock, smelt, and amphipods. The sample was small but important; it contributed to our still meager knowledge of the weaning food of the seal.

The question of processing the skins of old female seals continued to be troublesome. Scheffer and Johnson (1963)[42] developed a method for counting the number of fur-fiber bundles per unit area of skin, and for counting the number of fibers per bundle. The results showed nothing unusual about these parameters in females as compared with males. Why old female skins tend to lose fur during the unhairing process is still uncertain. Scheffer (1964) continued the study of pelage fibers and worked out a method making thermoplastic impressions of shaved skins. The skin of an adult female seal contains about 300 million fibers.

Following a study begun in 1958 of the commercial value of female skins, 117 skins of females of known ages 2 to 5 yr were collected in August 1961. They were later processed as conventional black-dyed skins; 72% of them graded as "Regulars" (Scheffer and Johnson 1962[43]). For sale purposes they were

[39]Lyons, E. T., and O. W. Olsen. 1962. Report on the eighth summer of investigations on hookworms, *Uncinaria lucasi* Stiles, 1901, and hookworm diseases of fur seals, *Callorhinus ursinus* Linn., on the Pribilof Islands, Alaska, from 7 June to 6 November, 1961. Unpubl. rep., 61 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[40]Peterson, R. S. 1962. Behavior of fur-seal pups during autumn; report of a preliminary study, 1961. Unpubl. manuscr., 59 p. Johns Hopkins University, School of Hygiene and Health, Baltimore, MD 21205.

[41]Peterson, R. S. 1963. 1962 summary of fur seal behavior study. Unpubl. manuscr., 9 p. Johns Hopkins University, School of Hygiene and Health, Baltimore, MD 21205.

[42]Scheffer, V. B., and A. M. Johnson. 1963. Report on a sample of sealskins taken on St. Paul Island, Alaska, in 1962. Unpubl. manuscr., 20 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[43]Scheffer, V. B., and A. M. Johnson. 1962. Report on a sample of female sealskins taken on St. Paul Island, Alaska, in 1961. Unpubl. manuscr., 13 p.

distributed among lots of male skins and they apparently returned an average of $107 each. A similar sample was taken the following year (Scheffer and Johnson footnote 42). By then, the biologists had realized that lumping experimental skins of females with conventional male skins was an unsatisfactory way of arriving at dollar evaluation. For the 1962 sample, they developed a system of "index numbers." The index number for a skin can be calculated immediately after grading. The 1962 sample suggested that the grade of a female skin begins to level off or decline in the "black-and-white-whisker" group of animals, ages 5 to 6. Samples of female skins were also taken in 1963, 1964, and 1965.

Fiscus collected fur seal hearts and livers at sea off California in early 1961 and delivered them fresh at the San Francisco dock to Thomas Richardson (Chemist, Bureau of Commercial Fisheries, Davis, Calif.). Richardson's interest was in fat metabolism as indicated by mitochondria. Public interest was developing in the whole problem of fatty foods versus human health and longevity.

Nagasaki (1961) made a thorough analysis of statistics of the Pribilof herd. It was a highly technical account which we are not prepared to evaluate. It represented the main contribution of Japan to the North Pacific Fur Seal Commission (1964) on the subject of fur seal populations.

Laurence Irving, known for his studies on the physiology of aquatic animals, visited St. Paul Island in 1961. With associates Leonard Peyton, Cordell Bahn, and Richard S. Peterson, he made studies of the maturation of diving adaptations and heat regulation in seals (Irving et al. 1962, 1963) (Fig. 14 top). He concluded that young seals can dive safely for 2 min, adults for 5-6 min. The large bare flippers enable the seal quickly to adjust to changes in the surrounding temperature.

William G. Reeder and Wallace I. Welker, of the departments of zoology and physiology, University of Wisconsin, were on St. Paul Island for a week in the summer of 1961. They collected perfused brains of three fur seals, the whole body of another, and the skeleton of three others. Through their work with Laughlin's team on Kodiak Island, they had developed an interest in identifying remains of marine mammals (Laughlin and Reeder 1962). Welker donated to the Marine Mammal Biological Laboratory in 1964 a plastic cast of a male fur seal brain.

Figure 14.—Top: Lawrence Irving (right) and Cordell H. Bahn (left) preparing to "testdive" a seal pup in a tank of seawater, St. Paul Island, in a physiological study; August 1961 (photo by V. B. Scheffer). Bottom: Shearing seal pups on Zapadni Rookery, 3 August 1963, to provide a basis for estimating the size of the population. Left to right in foreground: John Haxton, Ancel M. Johnson; left to right in background: Ken Thompson, Richard Stroud, Pete Dzikiewicz, Frank Reberger (photo by R. S. Peterson).

1962

The Standing Scientific Committee of the North Pacific Fur Seal Commission met in Seattle in February and March 1962. Committee members were G. C. Pike (Canada), F. Nagasaki (Japan), F. Wilke (United States), and S. V. Dorofeev (U.S.S.R.). Dorofeev died suddenly on 16 February and his place was taken by S. G. Fedorov. The report (North Pacific Fur Seal Commission 1964) was a very useful catalogue of biological data on the northern fur seal. It has not been equaled as an appraisal of the numbers, distribution, and economic status of the North American and Asian seal populations.

When the annual take of seal skins was increased in the late 1950's by the killing of females, the Fouke Fur Company moved to a larger factory in Greenville, S.C. Between June 1960 and December 1961, processing gradually came to a halt in St. Louis and increased to full tempo in Greenville. "The decision of the Company to relocate its complete operations without discussion with the Department [of Interior] and without regard to the public interest"[44] led to a break in the long series of contracts between the Company and the Government. The Interior Department gave other reasons, as well, for its decision to terminate the current contract on 31 December 1962 (Anonymous 1962).

An invitation to bid for a new contract was issued in June 1962 and four firms responded: Pierre Laclede Fur Co. (St. Louis), Supara, Inc. (Chicago), Fouke Fur Co. (Greenville), and Martin-Rice, Ltd. (London). Supara seemed to be the successful bidder, but the Attorney General in 1963 declared that the award was invalid. A new invitation was issued and three

Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[44]Interior Department, October 1961, 9 p. Washington, D.C.

firms responded in 1964: Superior Seal, Inc. (Chicago), Laclede, and Fouke.

A letter of intent covering a contract to Fouke was issued on 31 March 1965. The new contract specified that up to one-eighth of the raw sealskins would be retained annually for sale to other firms. A press agent wrote (on 7 May 1965) that the Government continues to be concerned with improving processing techniques as well as developing competitive "knowhow" in the handling of sealskins. Laclede was the first company to benefit by the experiment claus; it received on 1 September 1965 a contract to process 5,000 experimental skins.

On 13 April 1964, 206 tanned sealskins were donated to the Seattle Indian Center "to be handicrafted into small items of cultural, artistic, curio, or novelty nature" (Mammal Biological Laboratory, File 8.05.02). The skins had been variously bleached, dyed, and processed by Supara in competing for the Government contract. We mention the donation because it represents the first use in modern times of "government" sealskins for other than garments.

During the 8-yr period 1956-63, the herd reduction program on the Pribilof Islands had removed 270,054 female seals (Roppel et al. 1965b:8). One visible effect was the decline in numbers of females on hauling grounds. Where 16,498 females of ages 3 and 4 yr were killed in 1958, only 646 were killed during a comparable period in 1963 (Roppel and Davey 1963:16[45], 1965). Annual pup recruitment, mortality of pups on land, annual return of males, and pregnancy rate of mature females had not changed as expected (Roppel et al. 1963). The "biological momentum" of a large and complex herd could not quickly be altered by herd reduction at the intensity then practiced.

After the 1961 season, no record was kept of the field length of seals killed. Thereafter, when length was occasionally measured, it was only as a guide to the clubbers in selecting animals to be killed.

In the summer of 1962, William G. Reeder and James W. Nybakken (University of Wisconsin) spent 2 wk on St. Paul Island "making a preliminary study of fur seal vocal patterns, particularly those contributing to mother-young recognition" (Roppel et al. 1963:52; Peterson and Reeder 1966). Roppel collected skulls, bacula, and flippers for Reeder, who proposed to estimate age from calcium and phosphate content.

Tongues and larynxes of 25 fur seals and 5 northern sea lions were collected in 1962 and sent to Jean A. Pierard (New York State Veterinary College) as a contribution to his study of the comparative anatomy of these organs in carnivores (Pierard 1963).

Terramycin was injected peritoneally in two seal pups on 8 July 1962 and the pups were killed 10 d later. It was hoped that this drug would deposit in the teeth and bones, and that it could be used on a larger scale in the future for the internal marking of seals. Douglas Weber (Bureau of Commercial Fisheries, Fish and Wildlife Service, Seattle, Wash.) examined by fluoroscopy thin sections of the teeth of the two pups and found well-marked traces of the drug (Roppel et al. 1963:53; and unpubl. notes).

Selvig and Selvig (1962) compared the mineral content in dentin and cementum of fur seal teeth. We do not know where they got their specimens, the upper canines of three seals.

Mark Chenault Keyes joined the Laboratory as a veterinarian in 1962 and visited the Pribilofs that summer. He began to gather anatomical evidence that the conventional method of tagging seal pups at the wrist was injurious. By 1962, the evidence from 6 yr of pup weighing (in autumn each year about 1 wk after tagging) was conclusive that both males and females lose weight after tagging. The weight loss is partly overcome during the ensuing 2 mo.

Richard G. Bauer joined the Laboratory as a biologist in June 1962 and transferred to the U.S. Forest Service in May 1963.

Hundreds of dead seals approximately 2 and 3 yr old were observed on St. George Island in early September 1962. Food poisoning from "red tide" organisms (*Gonyaulax* spp.) was suggested as a possible cause of death, though there was no evidence of a red tide at the time. Similar mysterious die-offs had been reported from Caton Island, just south of the Alaska Peninsula, in 1934 (13 carcasses) and in 1941 (40 carcasses) (Scheffer 1950a:26).

Many years earlier, the death of a St. George Island woman had been ascribed to shellfish poisoning. In the island log[46] for 23 August 1878 (p. 165) the following statement appears: "At 11:45 a.m. the son of Zahar Oustigoff called his father from work to come and assist his mother who was sick and unable to walk. She had been under the cliffs west of the landing gathering fuel, and while on the beach had eaten some mussels or other shellfish . . . . The woman was taken to her house . . . but she became paralized (sic) very soon and died at 12:20 p.m. Good landing [the latter with reference to surf conditions]."

Biologists tagged newborn pups in late June 1962 and later recovered specimens of known ages 73 to 103 d. The dentitions were studied as evidence of the eruption and loss of teeth; pelage samples were studied as evidence of the mean date of molt from black to silver pelage. This date was estimated to be 13 wk after birth, or 7 October (Bauer et al. 1964b).

In the late 1950's, Rexford D. Lord, Jr. (Illinois Natural History Survey) had suggested that, since the eye lens in mammals apparently increases in weight throughout life, weight might be used as an indicator of age. Eye lenses of 181 seals were collected in 1958 and 1962 as a test of this proposition. Lens weight was found to increase geometrically in both sexes and was still increasing in the oldest specimens studied: a 14-yr male and a 21-yr female. "When only the lens weight and sex are known, the age of a seal can be identified to the nearest year through age 2" (Bauer et al. 1964a:374). In short, the method is too inexact to be valuable in fur seal research.

A 2-yr-old female seal tagged as a pup on a Soviet breeding island was recovered in Unimak Pass on 4 October 1962 (Fiscus et al. 1964:26). It was the first seal with a Soviet tag collected in eastern Pacific waters, though several had been recovered on the Pribilof Islands. No Soviet seals were taken through 1964 in North American waters south of Unimak Pass.

[45]Roppel, A. Y., and S. P. Davey. 1963. Evolution of fur seal management on the Pribilof Islands. Unpubl. manuscr., 24 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[46]Official Journal, St. George Island, Alaska. October 1870 - December 1886. (This journal is handwritten by the resident island manager.) Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

South of the Aleutians, Fiscus et al. (1964:40) found lactating females about 250 mi (400 km) from St. George Island and 290 mi (470 km) from St. Paul. This is evidence that seals may travel at least 500 mi (800 km) between successive nursing periods. It extends the feeding range as given by Lucas as "75 to 150 miles to the southward and eastward . . . of the Pribilofs" (Lucas 1899c:65).

Yearlings were first tagged in 1961 and 1962. Body weight was used in estimating age in 1961, body length in 1962. Length was the better criterion. It resulted in a sample containing more males than females; the known sex ratio of yearlings on land is about 4 males to 1 female (Roppel et al. 1963:27, table 18).

The first motion pictures for specific use in television were taken on St. Paul Island in the summer of 1962 by Warren Garst (Don Meier Productions), starring Marlin Perkins director of the St. Louis Zoological Park.

The by-products plant on St. Paul Island, built in late 1918, closed on 16 August 1961 after producing 312 tons (283 metric tons (t)) of seal meal and 52,458 gallons (198,575 l) of seal oil that summer (Power 1963:326). In 1962, an experiment in the salvaging of seal carcasses as food for ranch furbearers was attempted. Marine Products, Ltd., of Vancouver, British Columbia, spent 22-28 July off St. Paul Island icing down about 150 tons (135 t) of seal carcasses. These were unloaded in Vancouver on 9 August, barely short of putrid. In 1953 the company took about 250 tons (225 t) of seal carcasses.

In 1964, Pacific Fur Foods of Boring, Oreg., signed a 5-yr contract for carcasses and installed a sharp-freezer in the old by-products plant. The company used 85% of the carcasses from the 1964 kill on St. Paul and produced about 744 tons (675 t) of ground, bagged, frozen "sealburger."

Seal blubber continued to be saved as in the past, to be used in the processing of sealskins. From 100 to 200 barrels (55 gal capacity, 208.2 l) of salted, raw blubber are used each year.

In August 1962, Stuart P. Davey joined the Pribilof Fur Seal Program as the first Wildlife Management Biologist. Among his responsibilities were the gathering of routine biological data and the carrying out of routine biological operations. These included 1) age classification of the kill by tooth-layer counts, 2) recovery of tags, 3) application of tags, 4) bull counts, and 5) dead pup counts. Davey was also assigned the task of training five Pribilof Aleuts as assistants. The main idea was that a year-round resident management biologist and resident helpers would do many of the tasks that the Marine Mammal Biological Laboratory, with the help of college students enlisted in summer, had been doing. Davey resigned in autumn 1963 and his place was taken by Richard A. Hajny.

1963

On 8 October 1963 a protocol amending the Interim Convention on Conservation of North Pacific Fur Seals was signed in Washington, D.C., by representatives of the four parties (U.S. Congress, Senate 1963; U.S. State Department 1964). It entered into force 10 April 1964. It extended the Convention for another 6 yr, or until 14 October 1969. It relaxed certain research requirements such as the number of seals to be collected at sea by each party in each year. It changed slightly the apportionment of sealskins to Canada and Japan. At the request of Japan, it called for study of the "effectiveness of each method of sealing from the viewpoint of management and rational utilization of fur seal resources for conservation purposes (and) quality of sealskins by sex, age, and time and method of sealing" (Article II).

At the close of the 1963 season, a halt was called to "herd reduction," an operation which had been designed to reduce the herd to the level of maximum sustainable productivity. In the last year, methods of harvesting and curing had been so improved that over 97% of the female skins taken were cured; fewer than 3% were condemned and destroyed on the islands. Curing was performed for the first time in history by Government employees. Former employees of the Fouke Fur Company were hired by the Government to train new men in blubbering, brining, and the other operations of curing.

An important pup shearing program, designed to provide an early estimate of the population, was initiated in 1963 (Fig. 14 bottom). Galvanized stakes were set in concrete early in the summer to mark off sample transects; 21,929 pups were sheared in late July and early August (Roppel et al. 1965b:26-27). To obtain an estimate of the population, the marked-to-unmarked ratio in samples of 25 pups was ascertained a week or two after marking. From the results, it was estimated that 229,900 pups were alive at time of shearing on St. Paul Island. Next year, the same methods were used, though shearing effort was distributed within each rookery according to the harem bull count (Roppel et al. 1965a:18-20). In early August 1964, 27,716 pups were sheared; later in the month, about 21,000 pups were examined on sample plots; of these, about 1 in 9 was seen to be sheared.

To test the assumption that older and stronger pups will better survive the effects of tagging, a late-season operation was carried out on St. Paul Island in 1963. As a control group, 10,000 pups were tagged near the usual time, 12-21 August, while 10,000 were tagged between 20 and 26 September (Roppel et al. 1965b:12). The test was repeated in 1964 though, through a misunderstanding, the tagging site on the fore flipper was shifted 2 in (5 cm) for the September pups, thus introducing a new variable.

In 1963, the genital tracts of 310 known-age 3- and 4-yr females were examined with special reference to ovulation (Roppel et al. 1965b:11). A seal was classified as "preovulation" if her ovaries contained one or more Graafian follicles, each 5 mm or larger in diameter. She was classified as "postovulation" if one ovary contained a developing corpus luteum. The basis for judging postovulation was satisfactory; the postovulation rates were similar to the known pregnancy rates of 3- and 4-yr-olds. The criterion for preovulation gave results that could not be explained. The biologists concluded that many of the seals classified as "preovulation" do not in fact ovulate that year, or do not conceive, or lose the conceptus early in gestation.

The first general "glossary of terms used in fur seal research and management" was published in 1963 (North Pacific Fur Seal Commission 1963). It defined 114 terms. Some of the terms and several new ones, were later defined by Roppel et al. (1965b:36). Ten veterinary terms were defined by Keyes (1964: 71).[47]

[47]Keyes, M. C. 1964. Research in fur seal mortality, St. Paul Island, Alaska, 8 July to 24 September 1963. Unpubl. rep., 60 p. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

A skeleton of a fur seal was prepared in 1963 for use in the Marine Mammal Biological Laboratory. A rough-trimmed carcass was placed in Village Lagoon, St. Paul Island. Within a few days, large marine amphipods which swarm in these waters had cleaned off all but finer shreds of connective tissue.

The "seal-fish" *Bathylagus* spp. was identified in 92 seal stomachs collected in the Bering Sea in 1963 (Fiscus et al. 1964:13, 14). It had last been reported in seals in the 1890's.

Hiroshi Kajimura joined the Laboratory in November 1963 to assist in pelagic research.

Jones (1963) summarized reports that fur seals in winter occasionally cross the Alaska Peninsula. They may travel up to 3 mi (5 km) on land.

Yearlings were first tagged in 1961; tagged individuals were looked for and recovered on the killing fields in 1962. In 1963, the search for tagged yearlings was extended to the rookeries; 73 were found on St. Paul Island between 17 September and 17 October (Roppel et al. 1965b:18-19). When it was first being developed in 1963 the "yearling survey" required 2 d; later, when it was concentrated on nine sample plots, it required only 7 h. In 1964, a total of 47 tagged yearlings were counted (Roppel et al. 1965a:11).

During pelagic investigations in the Bering Sea in midsummer 1963, a special effort was made to collect and examine paired seals for evidence of mating at sea (Fiscus et al. 1965:7). Ten females from pairs were collected this year and seven in 1964 (Fiscus and Kajimura 1965:12). Sixteen of the 17 females had recently ovulated or were about to ovulate. One of the males persisted in staying near the dead body of the female. These observations suggested, but did not prove, that copulation may occur at sea.

Keyes began a study in 1963 of artificial diets capable of maintaining seal pups in captivity. (The problem is aggravating and of long standing. Zoo keepers over the world have difficulty in weaning young seals.) Earlier efforts by Olsen and Lyons had been unsuccessful. The 1963 experiment, utilizing 20 captive pups, was also unsuccessful; none of the pups gained weight, though one lived for 25 d (Keyes footnote 47, p. 2-21).

He isolated three organisms not previously known from the fur seal: *Proteus mirabilis, Aerobacter aerogenes,* and "*Streptococcus* sp. (probably *enterococcus*)" (Keyes footnote 47, p. 27). He found microfilariae in the blood of 35 of 40 bachelors, a suprisingly high incidence (Keyes footnote 47, p. 44).

He obtained good samples of seal milk which were analyzed by U. S. Ashworth. He reported on certain features of seal blood, heart rate, respiration rate, body temperature, stomach capacity, and speed of mammary regression (Keyes footnote 47, p. 56-57). In the field of pharmacology, he tested tranquilizing and anesthethizing drugs, anthelmintics, and milk-releasing drugs. He embalmed and injected a bachelor seal for anatomical study (Keyes footnote 47, p. 65).

One or more Fish and Wildlife Service biologists had been studying the fur seal herd almost continuously since 1940. In December 1963 the Service began to publish their research findings in two series of annual progress reports, one dealing with Pribilof studies and one with pelagic studies (Roppel et al. 1963; Fiscus et al. 1964). The publications were retroactive to the field season of 1962.

1964

In a critical study of fur seal population estimates, Chapman (1964) called attention to two basic unresolved questions. Why does the estimated number of pups-at-time-of-tagging vary widely from year to year—as much as 29%? Is the survival rate of females from birth to age 3 actually, or only apparently, greater than that of males? In answer to the first, he concluded that variation is mainly a result of tag-induced mortality. Tagged pups are more sensitive to environmental stress than are their untagged classmates; and since the tagged pups are the source of estimates, they unduly affect the estimates. In answer to the second question, Chapman used elaborate reasoning (which we will not detail here) to deduce that about 125 females survive to age 3 for every 100 males.

Allison M. Craig visited St. Paul Island in August to conduct experiments on the effects of pituitary extracts of seals on the reproductive organs of captive female seal pups. She was the first woman to engage in scientific studies of the fur seals on the Pribilof Islands. Her important paper on fur seal reproduction appeared the same year (Craig 1964). It presented new evidence that: 1) Follicular activity is not resumed until 6 mo after parturition in the ovary of the parturient horn. 2) First ovulation in the nulliparous female occurs in late August or September, 1.5-2 mo later than subsequent ovulations. 3) The percentage of 4-yr-olds ovulating is greater than the percentage of 5-yr-olds pregnant, suggesting a scarcity of breeding males when the young females first ovulate. (This theory is unconfirmed.) 4) After double ovulation, one blastocyst may migrate to the opposite horn, resulting in twins.

Craig coined the term "missed pregnancy" to describe failure of the reproductive apparatus (for any reason) between ovulation and implantation.

For 8 d, beginning 17 July 1964, during the kills on St. Paul Island, the minimum length limit was removed so that all 2-yr males appearing in drives would be taken (Roppel et al. 1965a:3). The immediate goal was to obtain a measure or index of the survival of the class of 1962; the final goal was to establish the relationship between the strength of any 2-yr class and the return of its survivors as 3-yr-olds the following year. A sample of 2-yr males was again taken in 1965, though only during 5 d, 22-26 July. Sampling was slated to be repeated in future years.

As 2-yr males were being sampled, they were also being measured. Never before had body-length measurements been obtained from a random sample of hauling-ground 2-yr males, unharmed by brand or tag. From the length frequency distribution of individuals taken during the sampling period in 1964 and 1965 it was possible to estimate the numbers of 2-yr males that would have been taken, had the entire sealing season been a sampling period.

From time to time since the 1890's, live pups have been counted on sample rookeries by either of the methods known as "running the gantlet" or "reconnaissance." An annual count was started at Kitovi Amphitheater in 1959, extended to Little Polovina in 1963, and to Zapadni Reef and part of Morjovi in 1964 (Roppel et al. 1965a:19).

The numbers of pups on uncounted areas have been estimated by extrapolation from counted ones through use of the "average harem" concept. (We have mentioned another, and distinct, series of pup counts designed to reveal the percentage of sheared among unsheared individuals.)

Roppel et al. (1965a:15-21) published a summary of pup population estimates through 1964. We give below data for the most recent year (totals for both sexes and both Pribilof Islands):

1. Based on counts of tags and tag-lost scars in the kill of males; numbers alive at time of tagging in 1962 ..... 372,882.
1a. Ditto, in the kill of females ..... 158,881.
2. Based on the ratio of sheared to unsheared live pups on sample plots; numbers alive at time of shearing in 1964 ..... 328,000.
3. Based on counts of live pups on sample plots, with the "average harem" method; numbers alive at time of count in 1964 ..... 285,000.

Methods of predicting the male harvest were first discussed in 1959. By 1964 the following methods were in use (Chapman 1965): Method 1) Based on the average relationship between the 4-yr kill and the 3-yr kill. Method 2) Based on the average relationship between St. Paul Island temperature during the gestation year and the survival of seals to killable age. Method 3) Based on the strength of the yearling class (as estimated from tag returns) and the survival of yearlings to killable age.

In the pelagic fur seal investigations of 1964, a 5-yr-old male was collected on the Farallon grounds, the oldest male collected to date in California waters (Fiscus and Kajimura 1965:9).

Fiscus and Kajimura (1965:16) concluded, from study of 1958-64 data, that the first fetus carried by a seal is more often in the left horn than in the right. The difference is slight, from 1 to 5% in favor of the left horn.

Keyes (1965:1-11[48]) picked up dead seal pups almost daily in July and August 1964 from a sample plot on Reef and autopsied 109. Malnutrition was the primary cause of death in 38% of the pups; injury in 17%; gastrointestinal and miscellaneous infection in 16%; other (and undetermined) in 18%; hookworm anemia in 12%.

He examined the stomachs of 336 seals taken at sea in 1964 and found ascarids in all but 4. In a subsample of 54 yearlings and 2-yr-olds, he found up to 480 worms per stomach.

Keyes applied a new kind of marker: a plastic tag on a stainless wire loop threaded through the nape skin of pups. He found that the insertion wound did not heal.

He obtained packed cell volume (hematocrit) values ranging from 18.5 to 50.5 in the blood of bachelors. This was the first attempt to establish normal values.

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Nongovernmental sources include scientific journals, such as the Journal of Mammalogy, and books, such as Elliott's *Our Arctic Province*. With the establishment of the U.S. Fish and Wildlife Service in July 1940, a "marine mammal research file" of manuscripts, field notes, photographs, punch cards, and other unpublished material has grown in the Marine Mammal Biological Laboratory, Seattle (at publication National Marine Mammal Laboratory, NWAFC, NMFS, NOAA, Seattle, WA 98115). It is the main source of information on scientific studies of the seal herd since 1940.

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